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ABSTRACT

This instructional unit deals with broadly based appreciation training in a range of skills that are appropriate to a wide sector of occupations, including engineering drawing, engineering materials, bench fitting, sheet metal work, turning, milling, welding, and electricity/electronics. The materials presented are intended for instructors and trainees to use as a reference work and self-teaching aid. The unit consists of an instructor guide booklet, two-part training guide, skill and training specification listing and checklist, booklet of trainee guide notes, off-the-job work record book, and work experience guide and log book. The two-part trainee guide contains instructional text covering the following topics: general safety; fire procedures; first aid; engineering drawings; care and use of measuring equipment; procedures in measuring and marking out; materials; hand tools; techniques in tapping and screwing; sheet metal work; techniques for joining, turning, and milling; oxyacetylene and manual metal arc welding, electricity, electrical conductors and wiring, solder, electronic components, and circuit boards. (MN)

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ED285002

Engineering Industry Training Board (EITB)

Foundation Training. Unit 1.

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ENGINEERING INDUSTRY TRAINING BOARD

E I T B FOUNDATION TRAINING

TRAINEE'S NAME

.....

TRAINING CENTRE

.....

SPECIFICATION FOR UNIT 1

Skill Specification

1. The safe use and application of a range of machine tools, hand tools and ancillary equipment necessary to carry out the skills listed in the Training Specification.
2. Reading and working to engineering drawings to BS 308 (1972) Parts 1 and 2 (Engineering Drawing Practice).
3. Using measuring and marking out equipment as outlined in the Training Specification in:

   (a) metric units
   (b) imperial units
4. Selecting and using appropriate cutting fluids and lubricants.
5. The application of workholding techniques and the correct methods for the basic practices appropriate to producing workpieces by milling and turning.
6. Using basic bench-fitting techniques to carry out simple operations as listed in the Training Specification.
7. The application of basic tools and equipment for the cutting and forming of thin plate material.
8. The application of basic welding practices by the oxy-acetylene and manual metal-arc processes.
9. Understanding the basic principles of electrical/electronic practices; and identifying, mounting and connecting simple electrical and electronic components.

Note: It should be possible for trainees to achieve at least the following standards at this stage:

Operation	Tolerances
Bench fitting	±0.4mm or ±0.016ins
Machining	±0.4mm or ±0.016ins
Marking out	±0.5mm or ±0.020ins
Bending and forming sheetmetal	±2.0mm or ±0.080ins

TRAINING SPECIFICATON

This Training Specification specifies the training which should be undertaken during Unit 1 of EITB Foundation Training

The boxes provided on the right-hand side of each page are to allow a record to be kept of your training.

Column A is for recording practices of skills during the training period.

Column B is for indicating that you have achieved an acceptable level of performance in the particular skill to the standards shown on the Skill Specification.

Column C is for entering a reference number relating to a job in your Work Record Book which includes that particular skill.

At the end of your training in Unit 1 the marked-up Training Specification and the Work Record Book will provide useful evidence of the work you have done during Unit 1 in order that you may progress to a further unit of Foundation Training.

SAFETY

The trainee must be given induction and safety training in all skill areas which form part of the programme irrespective of any previous training.

The trainee must have an understanding of the Workshop Statutory Requirements with regard to:

(a) Statutory requirements

The Abrasive Wheel Regulations 1970	
The Protection of Eyes Regulations 1974	
The Health and Safety at Work etc Act 1974	
The Factories Act 1961	
The Electricity (Factories Act) Special Regulations, 1908 and 1944	

(b) Workshop requirements

First aid procedures	
Accident procedures	
Fire hazards and fire fighting procedure	

(c) Personal protection

Protective clothing	
Manual lifting techniques	
Personal hygiene	

Engineering Drawing

		A	B	C
Understanding basic drawings, conventions and symbols to British Standard Specification BS 308	Dimensions			
	Abbreviations			
	1st angle projection			
	3rd angle projection			
Reading simple component drawings and extracting information correctly	Type of material required			
	Size and shape of material			
	Shape of component			
	Dimensions and tolerances			

Measuring and marking-out

Measuring, using	Rules/tapes			
	Calipers			
	Protractor			
Using	Radius gauges			
	Feeler gauges			
Measuring, using	External micrometers			
Marking out, using	Rules			
	Centre punch/scriber			
	Dividers			
	Scribing block			
	Squares			
	Protractor			
	Surface table/plate			
Marking out	Datums/guidelines			
	Angles			
	Radii/circles			

Materials

Identifying	Ferrous metals			
	Non-ferrous metals			
	Non-metallic materials			
Heat treating materials for	Hardening			
	Tempering			

Bench-fitting

Selecting and safely using hand tools				
Safely using	Drilling machines			
	Power driven hack saw			
Using	Cutting fluids/compounds			
Filing surfaces	Flat and square			
Removing surplus	Sawing			
material by	Chiselling			
Producing holes by	Drilling			
Finishing holes by	Countersinking			
Producing threads, using	Taps			
	Dies			
Fitting mating parts by	Filing			

Sheet Metal Work

Selecting and safely using hand tools				
Cutting thin plate using	Hand/bench shears			
	Guillotine			
Bending	Upstands			
	Box/tray sections			
Flanging	Boxes or cylinders			
Hemming	Single edges			
Forming	Cylinders or cones			
Producing holes, using	Bench/pedestal drill			
Joining, using	Mechanical fasteners			
	Rivets			
	Solder			

Turning

Identifying and safely using machine controls				
Selecting, setting and using cutting tools				
Selecting and using coolants				
Mounting and using	3 jaw chucks			
	4 jaw chucks			
Facing	To the centre of the work			
	A shoulder			
	To length			
Turning diameters	External			
	To a shoulder			
Centre drilling				
Drilling	Through workpiece			
	To a depth			
Thread cutting using	Taps			

Milling using Vertical or Horizontal Machines

Identifying and safely using machine controls				
Selecting and using coolants				
Positioning and securing	Vice to machine table			
	Workpiece in vice			
Positioning workpiece to	Machined faces			
cutter using	Marking out			
Milling faces	Horizontal			
	Vertical			
Milling stepped faces				
Milling slots	Open ended			
Milling faces having an	Single angle			
angular relationship	Vees			

Oxy-acetylene Welding

Safely operating oxy-acetylene welding equipment				
Producing fusion without filler				
Depositing a straight run with filler	Flat position			
	Vertical position			
Tack welding				
Welding in flat position	Close square tee fillet			
	Close outside corner			

Manual Metal-Arc Welding

Safely operating manual metal-arc welding equipment				
Striking and breaking the arc				
Depositing a straight run				
Tack welding				
Welding in flat position	Close square tee fillet			
	Close outside corner			

Electrical Wiring

Understanding basic electrical principles and safety procedures				
Reading electrical drawings and circuit diagrams				
Identifying and selecting cables and flexible cords				
Terminating and connecting cables				
Identifying electrical components				
Wiring circuits containing basic components	Plugs			
	Sockets			
	Switches			
	Fuses			
Testing electrical wiring for	Continuity			

Electronic Wiring and Assembly

Reading electronic drawings	Circuit diagrams			
Identifying	Wires/cables			
	Basic electronic components			
	Component boards			
	Component markings			
Mounting basic electronic components				
Soldering basic electronic components to component boards				

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INSTRUCTOR GUIDE NOTES

UNIT 1

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1 Introduction

1.1 These guide notes have been produced to provide assistance to instructors and tutors who are using EITB Foundation Training units within a Youth Training Scheme programme.

1.2 A YTS Course consists of a number of related elements designed to provide a coherent programme of basic training and education. When EITB Foundation Training Units are incorporated in the course it will have a bias towards engineering.

1.3 Each EITB Foundation Training Unit is designed for off-the-job training in a workshop which has been specially equipped to provide the facilities necessary for the introduction to basic engineering oriented skills. Off-the-job training is linked with work experience during which the trainee will undertake suitable tasks in a company or organisation and will learn about the way in which industry is structured and operates.

1.4 A component of further education, usually on a day release basis throughout the year, is also included in the scheme so that trainees can receive further tuition in subjects such as numeracy, communication, life and social skills, and basic engineering principles.

1.5 The Board has prepared Skill and Training Specifications to cover the off-the-job periods of training. The first period of such training is decribed in Unit 1.

1.6 All trainees should receive adequate induction training (see Appendix I).

2 Unit 1 Training (Off-the-job)

2.1 This unit deals with broadly-based appreciation training in a range of skills appropriate to a wide sector of engineering.

2.2 Off-the-job training takes place in a workshop area set aside for that purpose with qualified instructors and appropriate equipment.

2.3 This period of training covers a broad range of skills and two Training Guides Nos 1A and 1B have been prepared to give appropriate guidance on methods and job knowledge. The contents of these Guides are:

Guide No 1A	**Guide No 1B**
Safety	Turning
Engineering Drawings	Milling
Engineering Materials	Welding
Bench Fitting	Electrical/Electronic work
Sheet-metal work	

2.4 The guides are intended for use by instructors and trainees as a reference work and self teaching aid. The booklets describe techniques and skills by the use of illustrations and short text. The methods described are not the only ones which may be used and where other methods are used instructors are urged to check that these are safe and efficient before being used by trainees.

2.5 Attention is drawn to the importance of safety. It is essential to develop safe working habits from the start as an integral part of training. Safety points are emphasised throughout the text.

2.6 In order to assist in programme preparation and to monitor the progress of each trainee, the Board has produced a Skill and Training Specification for Unit 1. This specification identifies the practice requirements for trainees in each of the subject areas for this period of training.

2.7 The content of the Unit 1 Training Specification should require about 12 weeks, during which time each trainee will progress according to his or her aptitudes and abilities. Those trainees making good progress during the time allocated should commence Unit 2.

3 Implementing Unit 1 Training

3.1 Each trainee is issued with a Unit 1 Skill and Training Specification and Training Guides 1A and 1B at the commencement of training.

3.2 Trainees will be programmed to the following subject areas for appropriate training periods:
Drawing appreciation
Identification and uses of material
Marking out and measuring
Bench fitting
Sheet-metal work
Turning
Milling
Welding and heat treatment
Electrical/electronic wiring and assembly

3.3 Adequate emphasis must be given to safety and safe working practices at all stages of training.

3.4 Instructors should prepare a work programme for their own sections based on appropriate time periods to ensure that the trainees have maximum practices of the skills identified in the Training Specification and receive the relevant instructional content.

4 Monitoring Unit 1 Training

4.1 A series of columns of boxes are printed against each of the skills listed in the Unit 1 Training Specification.

4.2 During the training period, column 'A' of the specification is ticked to indicate each of the skills which is practiced by the trainee. Column 'B' is ticked if the trainee achieves an acceptable level of performance as outlined in the Skill Specification.

Example from Unit 1 Specification - Turning

		A	B	C
Turning diameters	External	✓	✓	
	To a shoulder	✓		
Centre drilling		✓		
Drilling	Through a workpiece	✓	✓	
	To a depth	✓		
Thread cutting using tap		✓	✓	

As this first period of training is only appreciation training it is not compulsory for the trainee to achieve the specified skill standard. However, where standards have been achieved and recorded in column 'B', this provides a useful indication of the trainee's aptitudes.

4.3 Trainees are expected to keep a work record in their log books for each task undertaken and column 'C' is provided to allow a reference number to be entered relating to the job which contains each particular skill.

Example from Unit 1 Specification - Bench Fitting

		A	B	C
Filing surfaces	Flat and square	✓	✓	8
Removing surplus	Sawing	✓		
material by	Chiselling	✓		
Producing holes by	Drilling	✓	✓	6
Forming holes by	Countersinking	✓	✓	6

5 Trainee Assessment

5.1 As well as recording the standards which the trainee achieves in the skill aspects of the Unit 1 training period, the instructor should from time to time assess the trainee in a range of other basic abilities in order to produce a Unit 1 Profile Record (See Appendix II).

5.2 A master chart is provided which lists a range of abilities including Social Abilities, Communications, Decision-making Abilities, Practical Abilities, and shows four levels of achievement in each of fourteen headings. The trainee is also provided with a summary sheet which is signed and dated by the Instructor as each level is achieved during the training period. At this stage it is not intended to give a detailed assessment under the the fourteen headings but to mark against the four main headings. (See Appendix III).

5.3 The instructor should keep a Progress Report (See Appendix IV) on each trainee.

6 Further Education

Trainees should attend a college of further education during the course and undertake an appropriate course which includes tuition on life and social skills, numeracy and communication as well as technical subjects. This course should normally be attended on a day release basis.

INDUCTION CHECK LIST

The main objectives of induction training are to:

a) Give the trainee an understanding of the training programme
b) Assist the trainee to adjust to the 'off-the-job' workshop
c) Assist the trainee to adjust to a company environment.

To ensure that the main topics of induction are covered, the following check list may be used. Each topic as completed should be ticked by the trainee and on being fully completed should be signed by the trainee and supervisor.

Location - 'Off-the-job' Workshop	**✓ on completion**
Purpose of Programme	
Content of Programme	
General Safety Requirements	
Documentation	
Financial Arrangements	
Training Materials and Records	
Further Education	
Certification	
Workshop rules and regulations	
Tour of the Workshop, Toilets, Canteen, and other facilities	
Welfare and medical facilities	

Trainee's Signature: .....
Supervisor's Signature: .....

Location - Company Premises	**✓ on completion**
Purpose of Programme	
Work Experience	
Documentation	
Financial Arrangements	
Further Education	
Log-book Record	
General Safety	
Company Rules and Regulations	
Job Responsibilities	
Tour of Works, including Medical Room, Toilets and Canteen	
Welfare and medical Facilties	

Trainee's Signature: .....
Supervisor's Signature: .....

TRAINEE PROFILE RECORD (UNIT I)

Name of trainee..... Date of Birth .....

When completed, this profile will show the various levels which the trainee has reached on leaving the course.

As the trainee improves abilities and skills, the instructor will initial and date the box indicating the level reached.

The instructor has a detailed definition of each of the four levels of achievement.

Ability	Level 4 (Basic)	Level 3	Level 2	Level 1 (Higher)
Social Abilities				
Communication				
Decision-making Abilities				
Practical and Numerical Abilities				

ATTAINMENTS IN BASIC ABILITIES

		4 (Basic Level)	3	2	1 (High Level)
SOCIAL ABILITIES	WORKING WITH COLLEAGUES 1	Can co-operate with others when led	Can work with other members of group to achieve common aims	Understands own position and results of own actions with a group	Is an active, decisive member of group. Helps and encourages others
	WORKING WITH THOSE IN AUTHORITY 2	Can follow verbal instructions for sample tasks and can perform them under supervision	Can follow a series of verbal instructions and carry them out independently	Can carry out a series of tasks effectively, given minimum instructions	Inspires confidence in those in authority and communicates well with them
	SELF-AWARENESS 3	Is aware of own personality and situation	Can determine own strengths, weaknesses and preference with some guidance	Has good basic understanding of own situation, personality and motivation	Has a thorough understanding of own personality and abilities and their implications
COMMUNICATION	TALKING AND LISTENING 4	Can hold conversations with workmates, face to face or by phone. Can take messages	Can follow and give simple descriptions and explanations	Can communicate effectively with a range of people in a variety of situations	Can present a logical and effective argument. Can analyse other's arguments
	READING AND WRITING 5	Can understand and write simple notices, labels and short notes	Can follow and give straightforward written instructions and explanations	Can use instruction manuals and can write reports describing work done	Can select and criticise written data and use it to produce own written work
	VISUAL UNDERSTANDING 6	Can interpret simple signs and indicators	Can, after guidance, make use of basic graphs charts, tables, drawings, etc.	Can interpret and use basic graphs, charts, tables and drawings unaided	Can construct graphs etc and extract information to support arguments
DECISION-MAKING ABILITIES	PLANNING 7	After demonstration, can identify the sequence of steps in a routine task	Can choose from given alternatives the best way of tackling a task	Can modify/extend given plans/routines to meet changed circumstances	Can create new plans/ routines from scratch. using all sources of help
	INFORMATION SEEKING 8	Can find information with guidance from supervisor	Can use standard sources of information	Can assemble information from several sources	Shows initiative in seeking and gathering information from a variety of sources
	COPING WITH PROBLEMS 9	With guidance, can cope with simple, everyday problems	Can cope with complex but routine problems. Seeks help if needed	Can cope with unusual problems by adapting familiar routines independently	Can offer sensitive and effective help to other people facing problems
	EVALUATING RESULTS 10	Can assess own results with guidance. Asks for advice	Can assess own output for routine tasks independently	Can assess own performance and identify possible improvements	Can identify other's difficulties and so help to improve group performance
PRACTICAL & NUMERICAL ABILITIES	USING EQUIPMENT 11	After demonstration, can use equipment safely to perform simple tasks	With guidance, can use equipment safely to perform multi-step tasks	Can select and use suitable equipment and materials for the job, without help	Can set up and maintain equipment. Can identify/ remedy common faults
	DEXTERITY AND COORDINATION 12	Can use everyday implements, can lift, carry and set down objects as directed	Can reliably perform basic manipulative tasks	Can perform complex tasks requiring accuracy and dexterity	Can perform tasks requiring a high degree of manipulative control
	MEASURING 13	Can read graduated linear scales and dials	Can measure out specified quantities of material by length, weight etc.	Can set up and use simple precision instruments	Can set up and use complex precision instruments
	CALCULATING 14	Can identify size, shape, order etc. Can add and subtract whole numbers	Can use +/-/×/÷ to solve single step, whole number problems. Can estimate	Can use +/-/×/÷ to solve two-step problems. Can add and subtract decimals	Can use +/-/×/÷ to solve multi-step problems. Can multiply and divide decimals

PROGRESS REPORT

Name .....

1st Period

EFFORT

Lazy — Industrious

1 2 3 4 5

CONDUCT

Irresponsible — Responsible

1 2 3 4 5

WORK RATE

Low — High

1 2 3 4 5

ABILITY

Failing Objectives — Achieving Objectives

1 2 3 4 5

2nd Period

EFFORT

Lazy — Industrious

1 2 3 4 5

CONDUCT

Irresponsible — Responsible

1 2 3 4 5

WORK RATE

Low — High

1 2 3 4 5

ABILITY

Failing Objectives — Achieving Objectives

1 2 3 4 5

3rd Period

EFFORT

Lazy — Industrious

1 2 3 4 5

CONDUCT

Irresponsible — Responsible

1 2 3 4 5

WORK RATE

Low — High

1 2 3 4 5

ABILITY

Failing Objectives — Achieving Objectives

1 2 3 4 5

4th Period

EFFORT

Lazy — Industrious

1 2 3 4 5

CONDUCT

Irresponsible — Responsible

1 2 3 4 5

WORK RATE

Low — High

1 2 3 4 5

ABILITY

Failing Objectives — Achieving Objectives

1 2 3 4 5

Signed .....

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EITB FOUNDATION TRAINING

TRAINEE GUIDE NOTES

UNIT 1

TRAINEE'S NAME

.....

TRAINING CENTRE

.....

Engineering Industry Training Board YT 14

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Trainee and Training Details

Surname	Forename(S)	Sex	Date of Birth
		M/F	

Home address	Next of kin	Location of Training Centre	
		Unit 1	Unit 2 (or 3)
		Date started	Date started
Telephone No.	Telephone No.	Date finished	Date finished

College of Further Education	Course of study

WORK EXPERIENCE LOCATIONS

Company
Name
Address
Contact
Telephone

Company
Name
Address
Contact
Telephone

Company
Name
Address
Contact
Telephone

Company
Name
Address
Contact
Telephone

(a) Enter your personal details on commencing the course.

(b) Enter other details as you continue your training.

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1 Introduction

1.1 These guide notes have been produced to explain the purpose and details of the EITB Foundation Training Units and to assist you in using the training material which is provided.

1.2 A Youth Training Scheme provides a programme of basic training and education. Where EITB Foundation Training Units are incorporated in the course it will have a bias towards engineering.

1.3 The course contains some off-the-job training in a workshop which has been specially equipped to provide the facilities necessary for the introduction to engineering type skills.

1.4 As well as off-the-job training there will be actual work experience during which you will work in a company or organisation and undertake suitable tasks. During work experience you will be given the opportunity to learn how industry is structured and how it operates. You will thus have some real experience of the world of work and be able to fit more easily into a future job or training programme.

1.5 Throughout the YTS Course you will be expected to attend a College of Further Education, usually for one day a week, so that you can learn about communication, basic engineering principles and life and social skills.

1.6 The EITB has prepared Skill and Training Specifications for off-the-job training and the first of these is explained in detail in this booklet and is known as Unit 1.

1.7 You will be given an adequate induction to your programme for the whole year including an introduction to safety matters. A check list is provided at the end of these guide notes for you to record coverage of each item (see Appendix 1).

2 Unit 1 Training (Off-the-job)

2.1 This Unit deals with broadly-based appreciation training in a range of skills appropriate to a wide sector of engineering.

2.2 Off-the-job training takes place in a workshop set aside for that purpose with qualified instructors and suitable equipment and machines.

2.3 The Skill and Training Specification Unit 1 contains details of the training which you will undertake and provides a record of your achievements.

2.4 Two Training Guides Nos 1A and 1B have been prepared to give guidance on the methods and job knowledge which you will use. The contents of these Guides are:

Guide No 1A	**Guide No 1B**
Safety	Turning
Engineering Drawings	Milling
Engineering Materials	Welding
Bench Fitting	Electrical/Electronic work
Sheet-metal Work	

2.5 These guides will be used by your instructor when teaching you skills and you will be able to refer to them to clarify any points which are not clear to you. As the methods shown are not necessarily the only way in which a skill may be performed, your instructor may prefer to demonstrate another method. He will make sure that it is safe and efficient before instructing you.

2.6 Attention is drawn to the importance of safety and it is essential that you develop safe working habits throughout your training. Read the 'Safety' section of Training Guide No 1A as soon as possible.

2.7 The content of the Unit 1 Training Specification should require about 12 weeks but the skills and standards which you achieve will depend upon your abilities. Trainees who make good progress during the time allocated may commence Unit 2.

3 Monitoring Unit 1 Training

3.1 The Training Specification specifies all the items which should be undertaken while working to Unit 1 in an off-the-job workshop.

3.2 Against each of the items in the specification you will find a series of boxes which will be used to indicate that you have practised each item and if you have achieved the standard shown on the Skill Specification.

3.3 Your instructor will help you fill in these boxes as you progress through the training programme.

4 Work Record Book

4.1 A Work Record Book has been provided for you to complete and this should show the work items that you undertake during your Unit 1 training.

4.2 Your entry should show a sketch of the jobs which you undertake; the details of dimensions, materials and operations; and any special feature which you may wish to note. Each entry should be given a reference number so that you can record in the appropriate box on your Training Specification, the Work Record Book entry which refers to each skill item. Try to keep your entries neat and clear.

5 Trainee Assessment

5.1 As well as recording the standards which are achieved against each skill item, your instructor will also assess the other abilities which we consider necessary for you to work effectively in industry.

5.2 Your instructor will consider your ability to work with others, to communicate, to solve problems and make decisions, and the way in which you carry out practical tasks. These will be marked at different levels and as you progress during training your improvements will be noted on a simple assessment form.

5.3 The levels of ability which you have reached by the end of Unit 1 training will be useful in determining the next stage of your course.

6 Further Education

6.1. Your workshop training will be mainly concerned with the development of skills and this will need to be complemented by information about basic engineering principles. This information will be obtained by attendance on day release to a College of Further Education.

6.2 In conjunction with City and Guilds of London Institute, suitable courses have been developed which should provide all the information you require.

6.3 Other subjects which will be covered during the course of further education include:

a) Communications - to help you develop the ways in which you receive or pass on information either by speaking, writing or using graphical methods

b) Numeracy - to emphasise the use of figures, measurements and symbols as applied to basic engineering problems

c) Life and Social Skills - to give you useful information on many of the subjects which you will come across during your work and other day-to-day activities.

6.4 You will be able to take appropriate examinations at the end of the course and receive certificates to record your achievements.

7 Work Experience

7.1 As well as completing Unit 1 training you will move to a suitable company to obtain experience in a real work environment.

7.2 Throughout your training remember the safety points which have been stressed and continue to ensure that you work safely both for yourself and others around you.

8 General

If you are in any doubt about your work programme or have other problems do not hesitate to inform your instructor.

INDUCTION CHECK LIST

The main objectives of induction training are to:

a) give the trainee an understanding of the training programme
b) assist the trainee to adjust to the 'off-the-job' workshop
c) assist the trainee to adjust to a company environment.

To ensure that the main topics of induction are covered, the following check list may be used. Each topic as completed should be ticked by the trainee and on being fully completed should be signed by the trainee and supervisor.

Location - 'Off-the-job' Workshop	**✓ on completion**
Purpose of Programme	
Content of Programme	
General Safety Requirements	
Documentation	
Financial Arrangements	
Training Materials and Records	
Further Education	
Certification	
Workshop rules and regulations	
Tour of the Workshop, Toilets, Canteen, and other facilities	
Welfare and medical facilities	

Trainee's Signature: .....
Supervisor's Signature: .....

Location - Company Premises	**✓ on completion**
Purpose of Programme	
Work Experience	
Documentation	
Financial Arrangements	
Further Education	
Log-book Record	
General Safety	
Company Rules and Regulations	
Job Responsibilities	
Tour of Works, including Medical Room, Toilets and Canteen	
Welfare and medical Facilities	

Trainee's Signature: .....
Supervisor's Signature: .....

TRAINEE PROFILE RECORD (UNIT 1)

Name of trainee ..... Date of birth .....

When completed, this profile will show the various levels which the trainee has reached on leaving the course.

As the trainee improves abilities and skills, the instructor will initial and date the box indicating the level reached.

The instructor has a detailed definition of each of the four levels of achievement.

Ability	Level 4 (Basic)	Level 3	Level 2	Level 1 (Higher)
Social Abilities				
Communication				
Decision-making Abilities				
Practical and Numerical Abilities				

TRAINING GUIDE No. 1A

SAFETY
ENGINEERING DRAWINGS
ENGINEERING MATERIALS
BENCH FITTING
SHEET-METAL WORK

ENGINEERING INDUSTRY TRAINING BOARD **YT 11A**

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Safety

Safe Practice for Engineering Trainees
You should acquire and practice safe methods of working and by the use of intelligence, initiative and knowledge ensure the safety of the workshop and remove the risk of injury or disablement to yourself and your colleagues.

Health and Safety at Work etc. Act 1974
It is a legal requirement that:

(a) "you shall take reasonable care for the health and safety of yourself and others who may be affected by your acts or omissions at work."

(b) "you shall not intentionally or recklessly interfere with or misuse anything provided in the interests of health, safety or welfare".

Statutory Requirements
There are a number of Statutory Regulations which refer to your dress and behaviour and to the way you undertake tasks in the workshop. The safe methods which your instructor will demonstrate are based on some of these Regulations, such as:

The Protection of Eyes Regulation 1974
The Factories Acts 1961
The Electricity Regulations 1908 & 1944
The Abrasive Wheels Regulations 1970

It is therefore very important that you only carry out work as demonstrated by your instructor in order to comply with the legal requirements of the Health and Safety at Work etc. Act 1974 as outlined above.

Safety Awareness
Genuine safety comes from following the example set by your instructor and developing 'safety awareness' which is the same as 'road sense' when driving.

Basic Points
The basic points of safety are easy to understand i.e.

(a) Learn the safe way of doing each task.
(b) If you do not understand – ask for an explanation
(c) If you are not taught – ask for instruction
(d) Use the safe method in practice
(e) Be constantly on guard against careless actions by yourself or others
(f) Practise good housekeeping at all times
(g) Co-operate promptly in the event of an accident or fire
(h) Report all accidents to an instructor
(i) Draw your instructor's attention to any potential hazard.

Think
The causes of the vast majority of accidents are not difficult to understand, for example:

(a) Sharp edges cut
(b) Heat or flames burn
(c) Acid destroys
(d) Gears, power driven rollers or other revolving parts can trap fingers or clothing
(e) Anything moving can be dangerous
(f) Anything heavy can be dangerous
(g) Electricity can burn or destroy
(h) Falls can injure
(i) Anything incorrectly supported may fall.

The ways in which these dangers may appear in the workshop will be explained by your instructors.

Before commencing a job and knowing the possible causes of injury:

(a) Look at the working situation and consider the job about to be performed
(b) Identify which dangers are present and take the necessary precautions
(c) Make sure that guards are in position and correctly adjusted
(d) Check your instructions.

Not all dangers are immediately obvious.

For instance, when a grinding wheel is in action it will be seen that sharp edges cut and that anything moving can be dangerous. More than this however, a damaged or improperly mounted grinding wheel can burst at speed. For this reason the mounting of grinding wheels by persons other than those trained and appointed for the purpose is prohibited by the Abrasive Wheels Regulations. You must not change a wheel unless you have been trained and appointed to do so.

Emergency
It can be foreseen and it can be planned for, but there will be no warning. This is why emergency drills are practised.

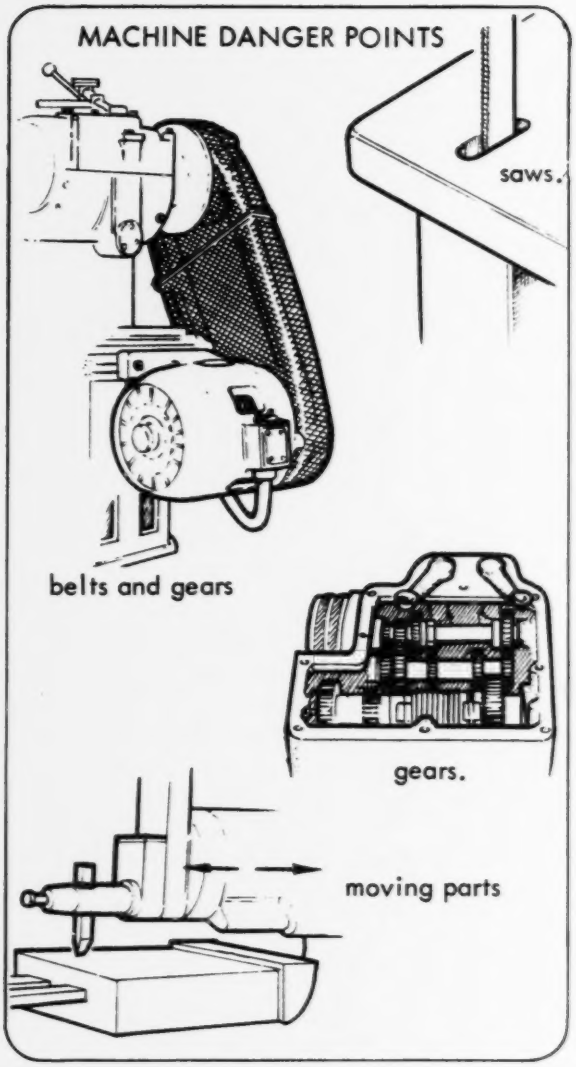
Action in case of emergency
The first person, whether staff or trainee, to become aware of an emergency is responsible for starting the necessary action by giving the alarm. It is essential that you know the position and method of operating the fire alarm and also the emergency stop system.

Operation of the emergency stop system will shut down all machinery in the area and is to be used whenever a person is trapped in a particular machine and time would be lost in reaching the switch of the machine concerned.

> The first objective in any emergency is to prevent loss of life, further injury to a victim, or injury to other personnel.

In the case of a fire, there will be a defined drill which will go into operation as soon as the alarm is sounded.

Where there is an accident and the victim is still trapped, shut down the cause of the accident e.g. the machine, the power supply, gas or compressed air, and then summon assistance.



Ensure that you know who is qualified to render first aid in the work area. If you receive an injury however minor, you must report to the first aid man.

Should you become aware of a hazard that could cause an accident you must draw it to the attention of an instructor.

The Training Centre

Safety in the Training Centre is based largely on the rule 'A place for everything and everything in its place'. This is not a finicky request from some over-zealous instructor, but good common sense.

In practice it means that

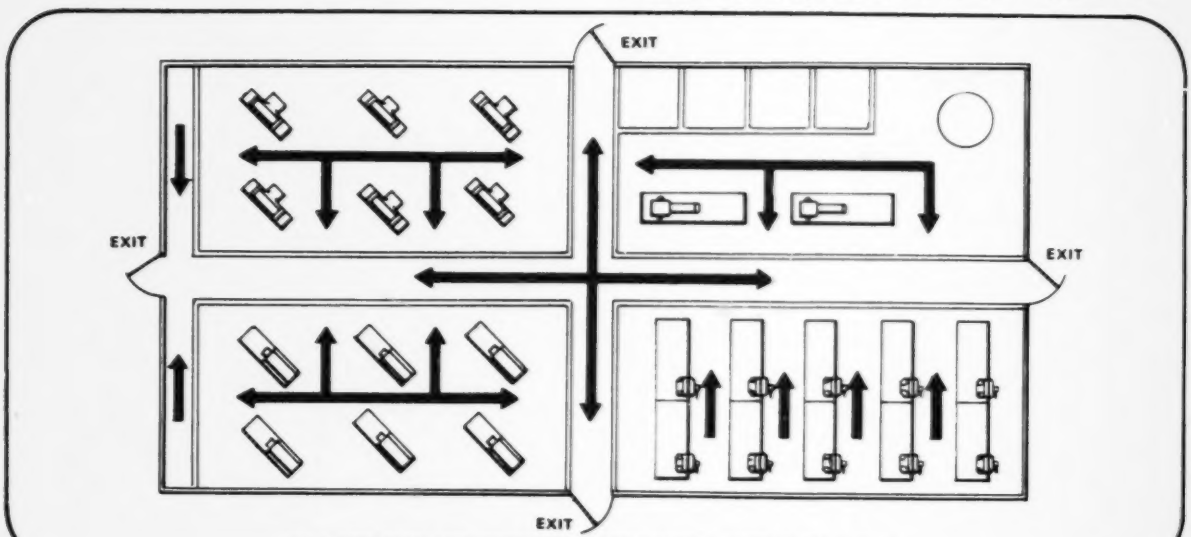
gangways are clear of obstacles over which you may trip into something dangerous;

guards protect you from moving parts of machinery;

you do not tread on, sit on, or put your hand on, some sharp edged or pointed tool or object left lying around by a thoughtless individual.

It has the added advantage that you are able to find a particular object with the minimum of delay especially in an emergency when time can be vital.

It is also important to clean up all spilt liquids or splashes of grease. Invariably an emergency leads to rapid movement by people. If anyone falls because of a patch of oil, apart from injury to oneself the delay could be disastrous to others.

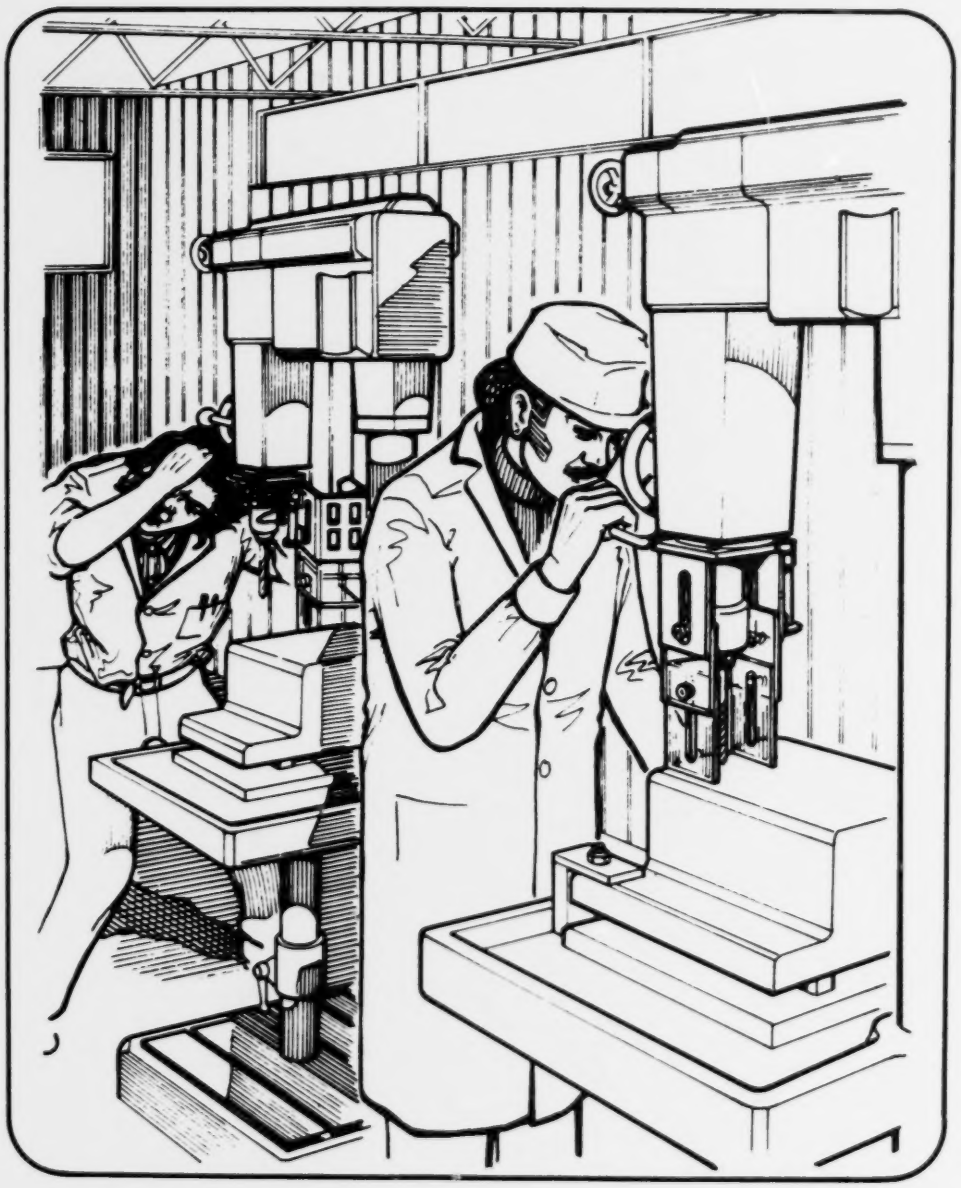


ALL GANGWAYS ARE POSSIBLE ESCAPE ROUTES. KEEP THEM CLEAR

Safety Hazards

Machines and powered tools
Machines in motion are always a hazard, and a trap for the unwary. Compared with man, they are very powerful and for this reason no risks must ever be taken when operating them. Untidy hair or clothing is easily caught by unguarded moving parts of a machine, leading to damage for the individual who is caught. The first line of defence is to ensure that the guard is always in position and properly adjusted for the work.

The instructor is not being 'fussy' when he pulls you up for untidy dress. He is just trying to teach you safe habits of work.



4

Hand Tools
Whilst it may appear funny to see a man strike his thumb with a hammer, it is never amusing for the individual concerned. Remember that the laughter of others is not at the pain caused but at the foolishness of the man inflicting it on himself. Injury from hand tools is frequently caused by stupidity, carelessness or distraction.

Horseplay
This is a most dangerous practice, often resulting in injury or death, and is strictly forbidden. Employees have been prosecuted by the factory inspector for ignoring this rule. Learn to appreciate the power of the equipment used. For example a compressed air gun can be as lethal as a revolver and should never be playfully used.

Electricity
The power of electricity is well known. It is vital however to remember that it is invisible. Because its presence is sometimes made obvious by lights or dials its invisibility is often forgotten. Never assume that any equipment which is fed by an electric cable is dead; always check with your instructor. Even this precaution is not sufficient with equipment heated by electricity; it still takes time to cool down.

In a factory the law forbids your doing electrical work where you are at any risk unless you are competent to do so. Do not meddle with electrical matters – leave them to the electrician.

If you are to become highly skilled in electrical work you may become what the Factories Act Electricity Regulations call an "authorised" or "competent" person. As such you are allowed to perform work where technical knowledge or experience is required to avoid danger. The safety training which is started at this stage, and which will continue until you have completed your course, will give you the basic understanding and skill to enable you to follow the safety precautions required. Training alone, however, cannot protect you. You must always act in a safe and responsible way when dealing with live equipment. The safe way of doing the job must become second nature to you.

Trainees
The danger from loose, untidy clothing and hair has already been stressed, but there are still your eyes, ears, hands, feet, arms, legs, head and back that must be protected at all times. Curiously, these are items about which people are inclined to be careless and a workshop is a dangerous place for a careless person.

Your instructors will highlight the hazards and how to protect yourself from them. All the information you need to learn for your chosen skill is available and offered.

It is not feasible to describe every cause of accidents but it is possible to learn to appreciate circumstances, methods and conditions that can produce hazards. There is a lot of truth in the statement that accidents do not happen – they are caused.

Some Safety Pictorial Signs

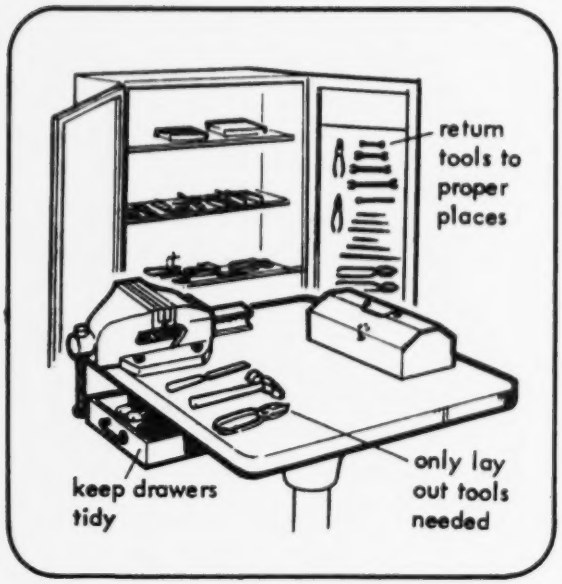
Prohibitive
Black pictorial signs on white background, inside a red circle with a red diagonal bar indicate forbidden actions. A simple example would be a cigarette in a red circle meaning 'no smoking'.

Safety Instruction
Pictures, usually white, on a blue disc are safety instructions such as 'Wear goggles', 'Wear hard hat' or 'Wear ear muffs'.

Caution
Signs, usually black, contained in an orange yellow triangle are cautions. These must be learnt as they are not necessarily obvious. The example shown indicates 'flammable material'.

Safety Information
A rectangular sign with a green background and usually in white is instruction information showing the location or direction of a safety facility such as first aid . . .

. . . or an emergency exit.



General Behaviour

Everyone must move about the workshop with care. Never run.

The gangways must be kept clear.

Never try out or use machines unless authority is given.

Walking under suspended loads should be avoided.

Practical jokes are a serious danger; they are forbidden.

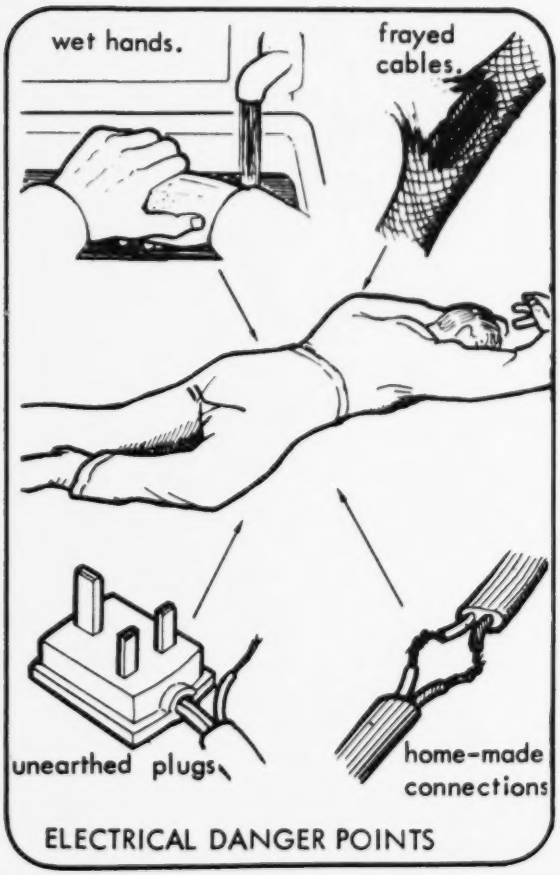
Housekeeping

The bench must be kept neat and tidy. Only the tools required for the job should be on the bench. Every tool should have its proper place.

The floor must be kept clear and clean. Use separate bins for waste rags and dirt. Wipe up spilt oil at once.

Important

Sharp tools must always be carried with their points downwards, and where possible with the sharp edges protected. Sharp tools, marking out and measuring instruments, such as dividers and scribers must not be carried in overall pockets. Defective tools must never be used. When working overhead, tools must be attached to safety lines.



ELECTRICAL DANGER POINTS

Electricity

No defective electrical equipment may be used. Any faulty electrical equipment must be reported immediately.

Electrical equipment must never be touched with wet hands.

Frayed wires are dangerous and must be reported.

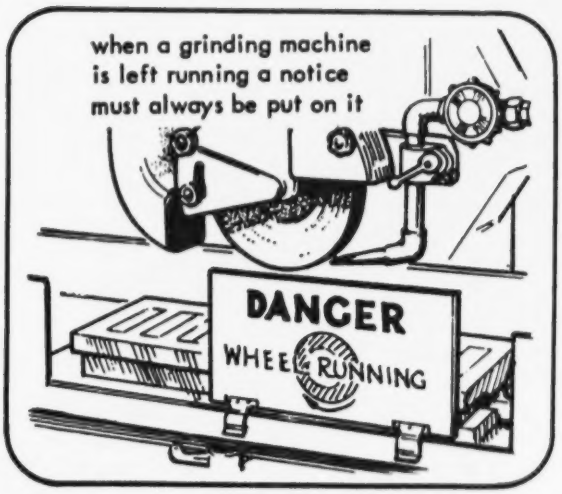
Electrical connections must always be made by an authorised person.

Electrically-driven hand tools must be properly earthed: if the earth wire is not connected to the earth pin, the outer casing can become live and give a fatal shock. If in doubt about earthing, an instructor should be consulted.

Power tools should never be connected to a lamp socket, as these have no earth connection.
Electrical hand tools must be properly insulated.
Trailing wires can cause an accident.
Danger notices mean what they say.

Compressed Air
Compressed air is very powerful and its misuse can be very dangerous. Air lines must only be used for the purposes intended.

Compressed air can drive particles of dust and swarf through the skin which can cause blisters. It must never be directed towards the skin or clothes.



Machines
Take care when walking about, particularly where there are overhead drive belts. The driving shaft should not be touched under any circumstances by unauthorised persons. Only the belt shift mechanism should be used for changing speeds.

Before starting a machine, the trainee must know how to stop it. Most machines must be switched off when not in use. If, for any reason, a machine must be left running and unattended, for example a grinder, a clearly visible notice should be put on it.

Fire procedures

General

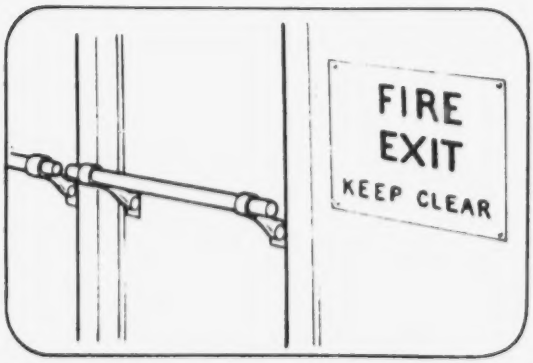
When an outbreak of fire is discovered, **immediate, correct** action is essential in order to provide the best possible chance of putting it out quickly, thus reducing danger to life, and damage caused, to the minimum.

All personnel must be fire conscious and must know the fire drill, position of the nearest fire point and the nearest telephone or fire alarm.

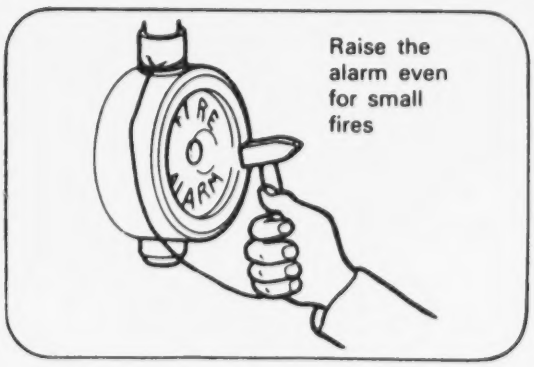
Whenever equipment which could give rise to a fire hazard is used, such as blowlamps, or welding torches, a suitable fire extinguisher should be placed within easy reach.

Fire drills and precautions

Fire drill
Fire drills and orders should be displayed on all section notice boards and at all fire points. All personnel must make themselves familiar with those orders, which should cover the following points:
(a) sounding the alarm
(b) informing the Fire Brigade
(c) evacuation of the premises
(d) assembly
(e) roll-call
(f) fire fighting, pending the arrival of the Fire Brigade.



Fire exits
Fire exits and escape routes should be clearly marked and must be kept free from obstructions. You should always know the way to your nearest fire exit.



Raising the alarm
As soon as fire breaks out, raise the alarm.

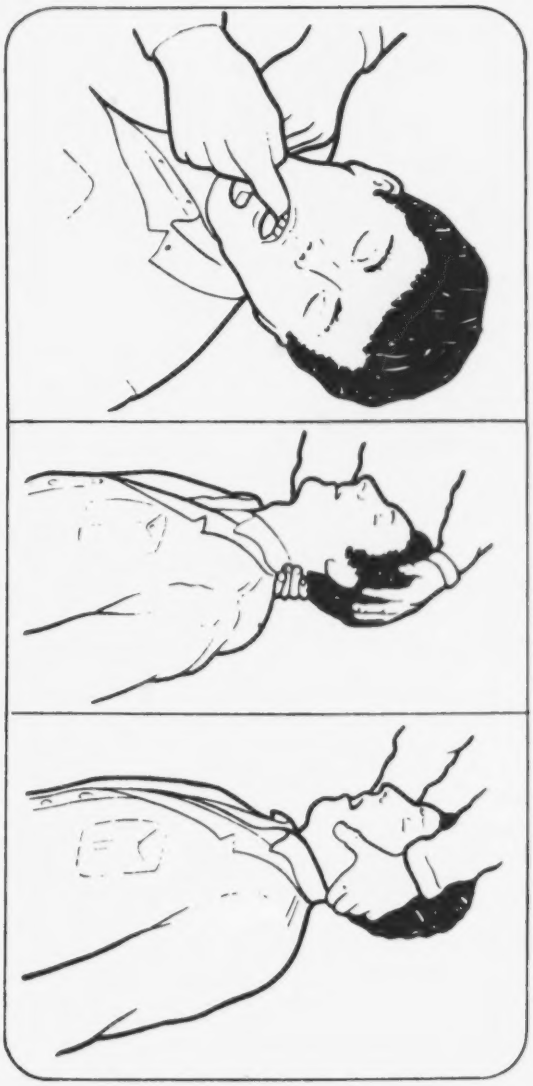
Procedure in the Event of Accidents

General
No unqualified person should attempt to render first aid except to try to save a life in extreme emergency when:

(a) breathing has stopped
(b) bleeding is severe.

Everyone must know the procedure for obtaining medical aid, or for summoning a doctor and ambulance.

At all times, the position of the nearest telephone and the nearest first aid box must be known.



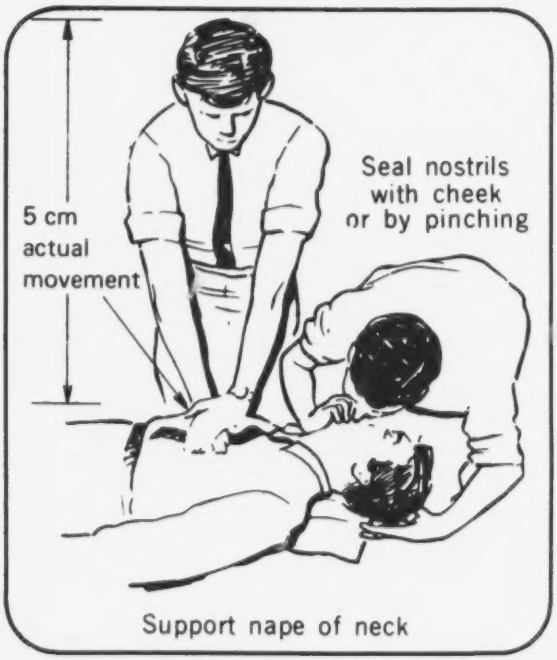
First Aid to Save Life
If breathing has stopped, apply immediate artificial respiration.

Mouth to Mouth Artificial Respiration
(a) Remove any obstructions from the mouth.

(b) Support the nape of the neck and press the top of the head backwards.

(c) Press the angle of the jaw forward from behind to ensure that the tongue is forward and the airway clear.

(d) Open your mouth wide and take a deep breath. Pinch the patient's nostrils. Seal your lips round his mouth. Blow gently into his lungs until they are filled. Remove your mouth and watch the patient's chest movement. When exhalation is complete repeat procedure until patient breathes by himself.



If an assistant is available, HEART MASSAGE may be employed to assist recovery by improving the circulation of the blood.

1. Kneel alongside the victim's chest.

2. Place the heel of the right hand on the lower end of the victim's chest bone.

3. Place the left hand on top of the right hand.

4. Keep the arms stiff and rock forwards so that your weight depresses the victim's chest by 3 to 5 cm (NOT MORE THAN 5 cm)

5. Repeat this movement steadily at one-second intervals. Erratic or violent action is dangerous.

When working alone, heart massage may still be applied while carrying out mouth-to-mouth respiration.

1. Kneel alongside the victim's chest.

2. Carry out inflation a few times as previously described.

3. Change to the heart massage position and depress the chest five times at one-second intervals.

4. Give another inflation.

5. Repeat heart massage five times. Continue to alternate with one inflation and five chest depressions until help arrives.

Treatment of Electric Shock

Prompt Treatment is Essential

If assistance is close at hand, send for medical aid then carry on with emergency treatment.

If you are alone, proceed with treatment at once.

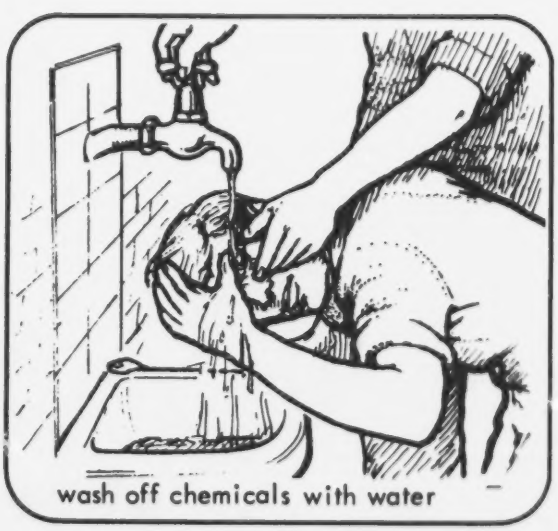
Switch off current, if this can be done without undue delay. Otherwise, remove victim from contact with live metal, using dry, non-conducting materials such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled-up newspaper, non-metallic hose, P.V.C. tubing, bakelised paper tube.

DO NOT touch the victim until contact with the electrical source is broken.

Wrap your hands in dry material if rubber gloves are not available.

Electrical Burns

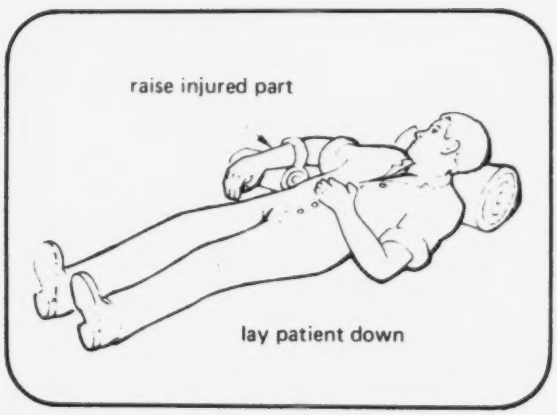
A person receiving an electric shock may also sustain burns when the current passes through his body. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally unaided.



Burns and Scalds

Burns are very painful. If a large area is burnt, give no treatment, except to exclude the air, e.g. by covering with water, clean paper, or a clean shirt. This relieves the pain. If a burn has been caused chemically, i.e. by an acid or an alkali, the chemical must be washed off with clean water.

Severe bleeding
Any wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive professional attention. As an immediate first aid measure, pressure on the wound itself is the best means of stopping the bleeding and avoiding infection.



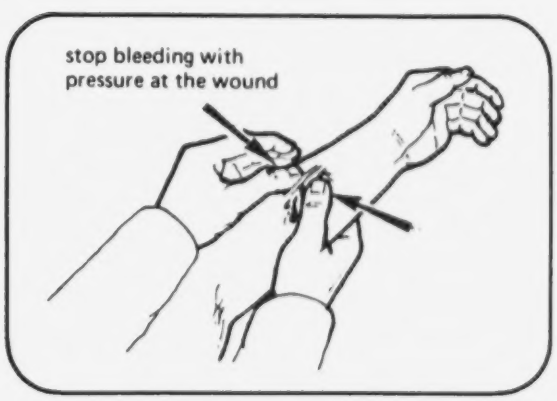
Immediate action
Always in cases of severe bleeding:

(a) Make the patient lie down and rest.

(b) If possible, raise the injured part above the level of the body.

(c) Apply pressure to the wound.

(d) Summon assistance.



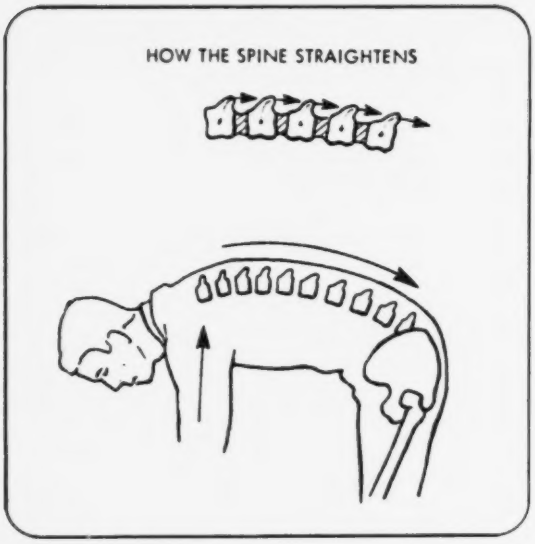
To control severe bleeding
Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding. When the bleeding has stopped, put a dressing over the wound, and cover it with a pad of soft material.

For abdominal stab wounds, such as caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

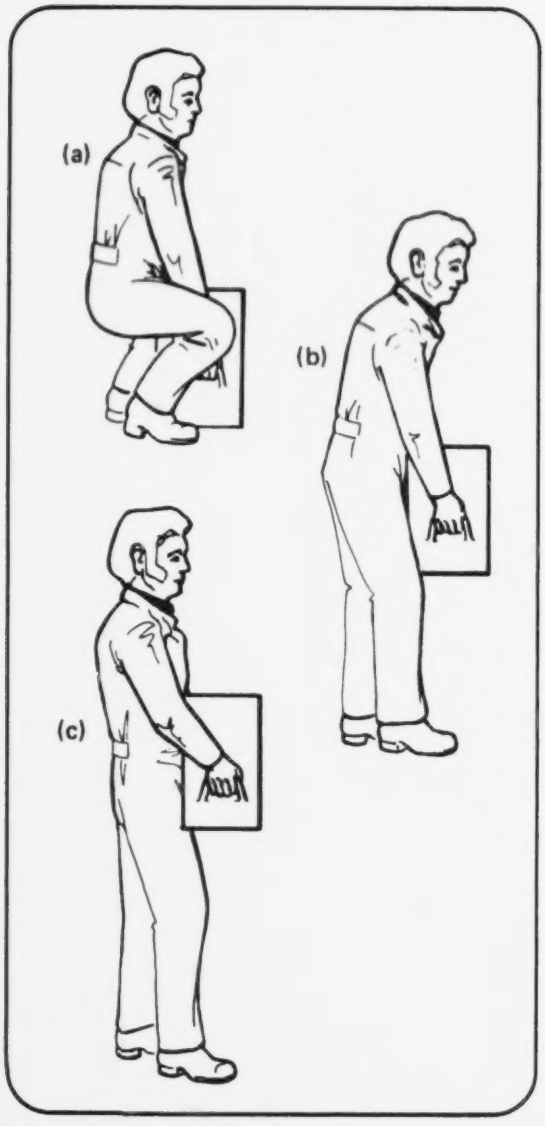
For larger wounds, apply a clean pad (preferably an individual dressing) and bandage firmly in place.

If bleeding is very severe apply more than one dressing.

Manual Lifting Techniques



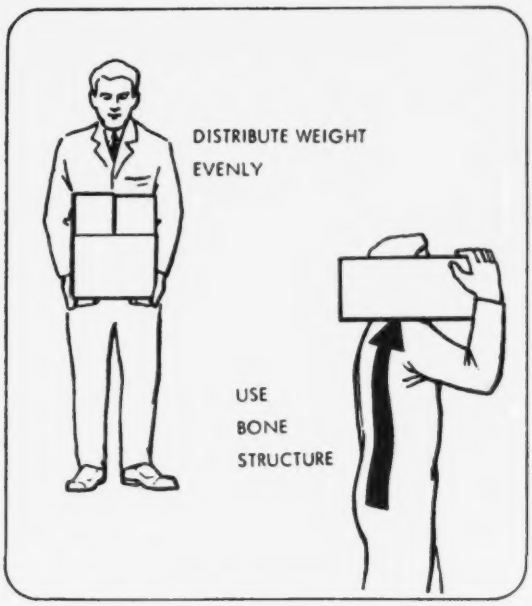
Correct Manual Lifting Technique
Correct lifting techniques must always be used. The human spine is not an efficient weight lifting machine and can be easily damaged if incorrect techniques are used.



(a) The lift should start with the lifter in a balanced squatting position, with the legs hip width apart, one foot ahead of the other, and the load to be lifted held close to the body. Ensure that a safe secure hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. The chin should be drawn in with the head up. This helps to keep the spine rigid.

(b) To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.

(c) To complete the lift, raise the upper part of the body to the vertical position.



Principal Rules for Holding and Carrying

1. Keep the body upright when carrying a load and hold the load close to the body.

2. Distribute the weight of the load evenly.

3. Let the bone structure of the body support the load.

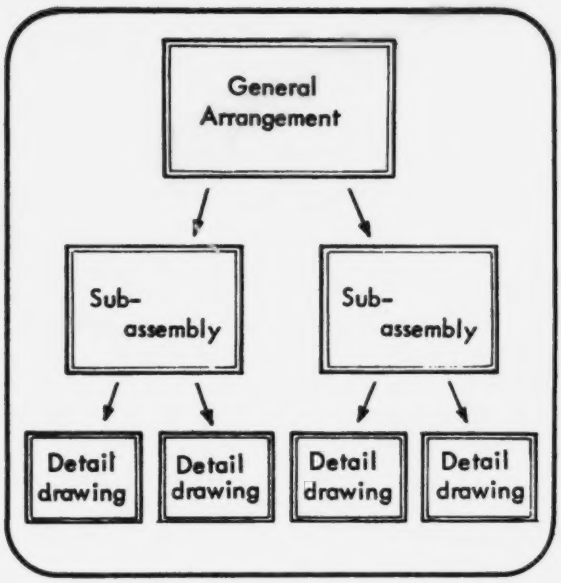
4. Use aids such as harness, straps and yokes.

Protection against injury
The risk of injury and damage to equipment may be reduced by the taking of simple precautions before lifting and manhandling operations begin.

The area of operation should be clear of obstructions.

All movable objects which could be considered as obstructions should be moved to a safe place.

Engineering Drawings



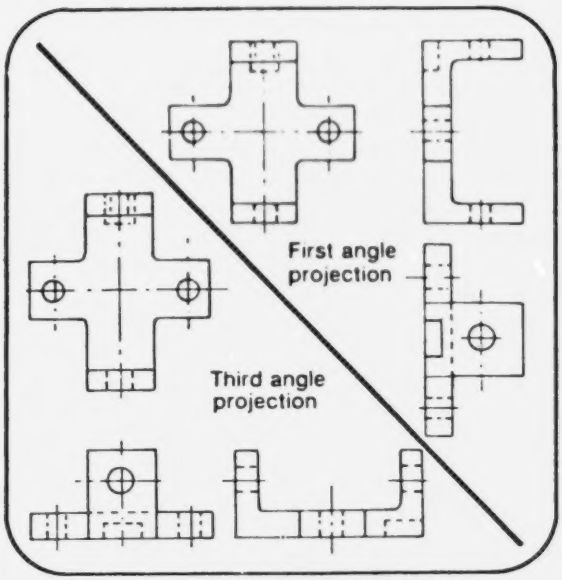
Engineering drawings give information about shapes, dimensions, surface finishes, materials, assemblies and connections of components to enable the reader to understand what has to be made.

Drawings
Main forms of drawing are:

1. General Arrangement drawings which show the complete arrangement of all the components.

2. Sub-Assembly drawings which show in greater detail the way parts are assembled.

3. Detail drawings which show the details of individual manufacture.



Two systems for projecting drawings are in common use.
First angle system
Third angle system
The drawing should be clearly marked First or Third angle projection, to indicate the method used.
Alternatively, the direction in which the views are taken should be clearly indicated.

Before starting work:

1. Check that the drawing is of latest issue.

2. Check the projection and scale of the drawing.

3. Confirm that the drawing is reliable by checking the dimensions given against existing machines or structures.

4. Check that units of measurement are stated correctly.

5. Confirm that all features are shown.

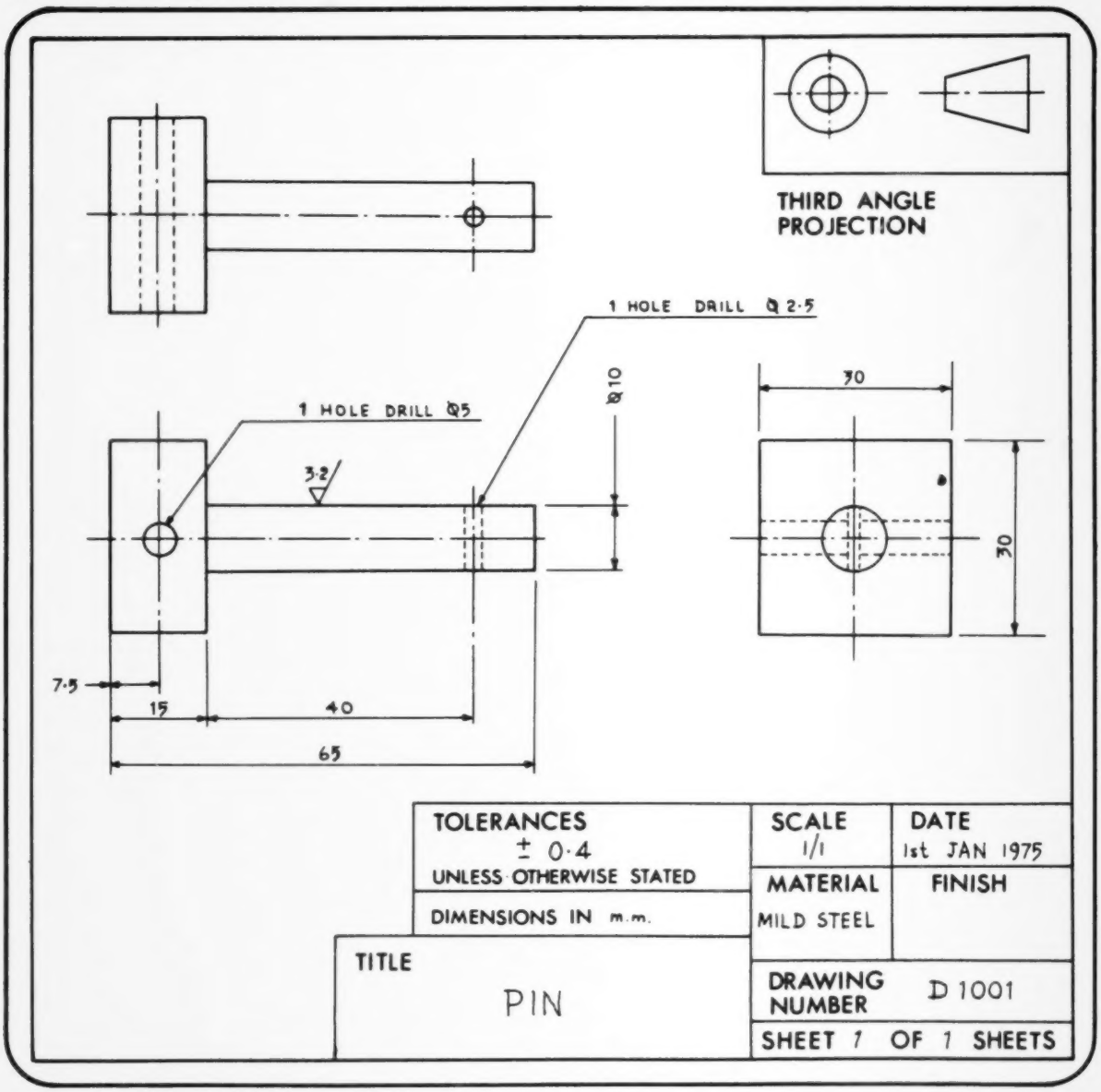
6. Confirm that all dimensions required for the work are shown on the drawing.

7. If in doubt about any details on a drawing obtain answers to all queries before commencing work.

To read engineering drawings correctly, a knowledge of drawing conventions is essential. Careful attention must be paid to B.S. 308 which is the British Standard for engineering drawings.

Reading a simple component drawing

Engineering drawings give information about shapes, dimensions, surface finishes, connections and assemblies of components to enable the reader to understand what has to be made.



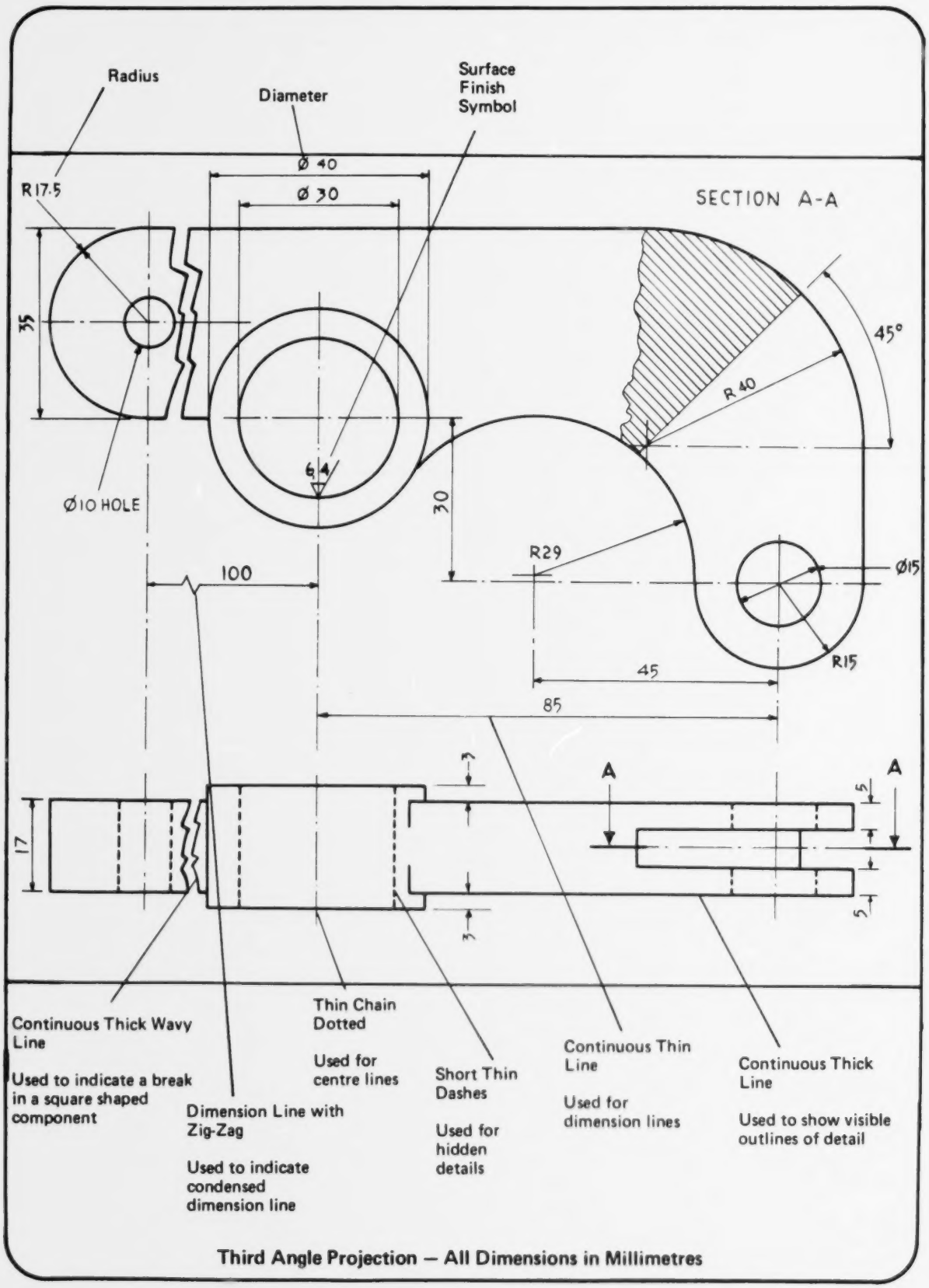
The above drawing is a detail or component drawing which shows details of the individual part.

Reference should be made to the latest issue of B.S. 308, Engineering Drawing Practice for details of projections and drawing conventions.

Main Features

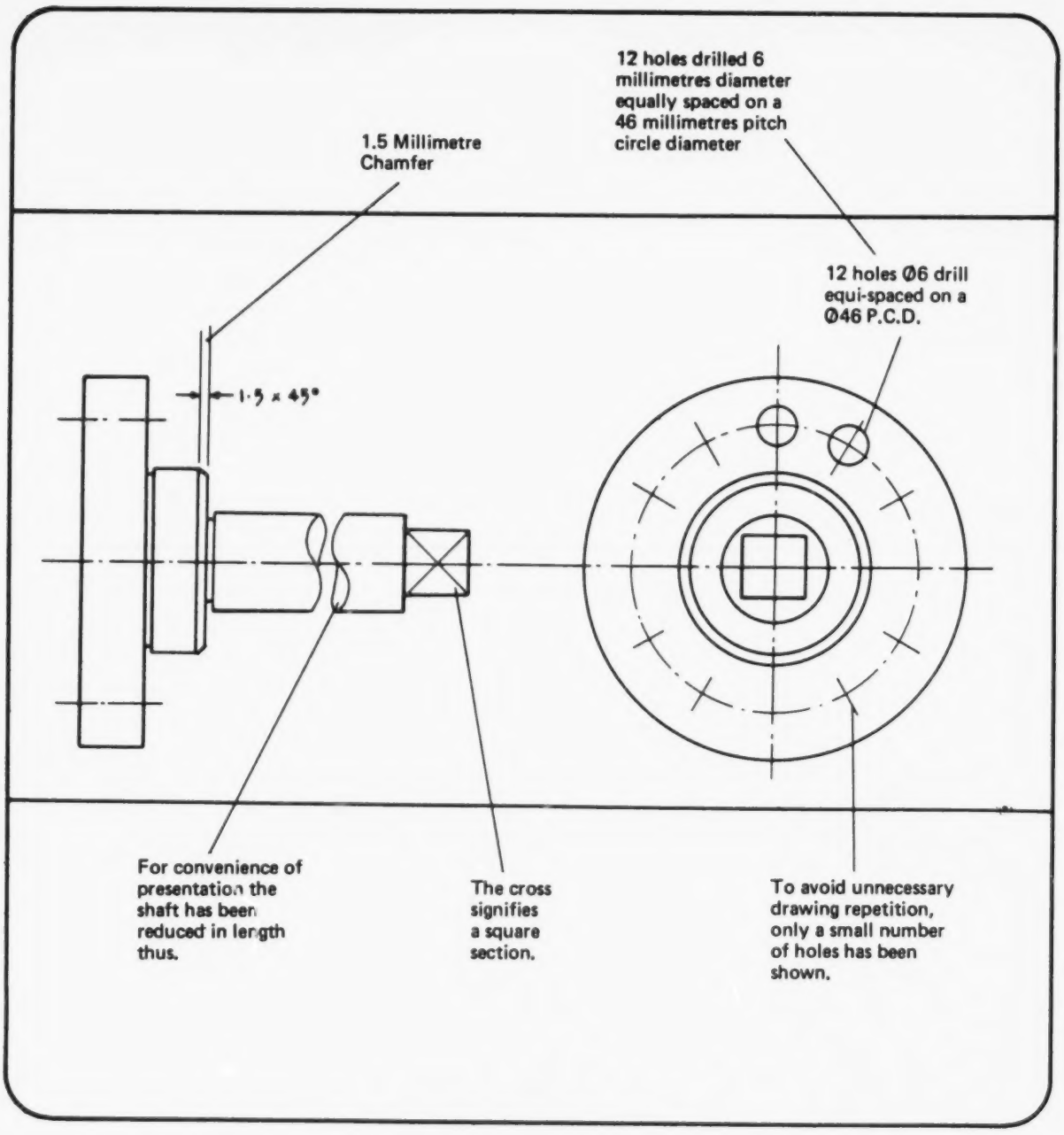
1. Type of material
2. Size and cross-section of material
3. Shape of component
4. Nominal sizes of component
5. Limiting dimensions and tolerances
6. Quality of surface finish

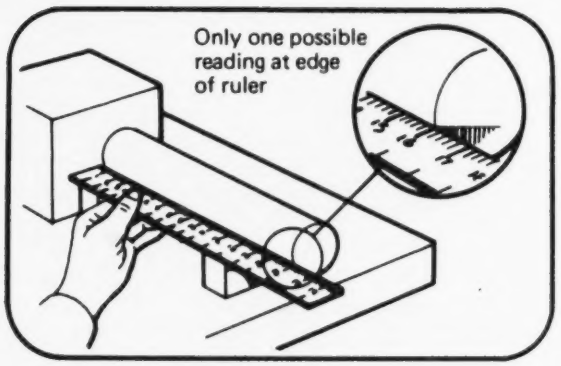
Explanation of the meaning of standard types of lines, symbols and abbreviations



Third Angle Projection — All Dimensions in Millimetres

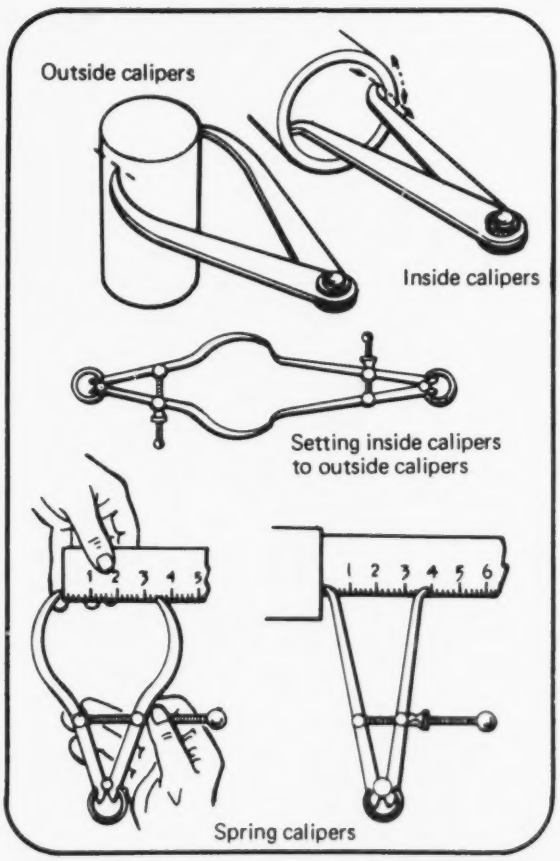
Further Example of Drawing Conventions


12 holes drilled 6 millimetres diameter equally spaced on a 46 millimetres pitch circle diameter
1.5 Millimetre Chamfer
12 holes Ø6 drill equi-spaced on a Ø46 P.C.D.
1·5 x 45°
For convenience of presentation the shaft has been reduced in length thus.
The cross signifies a square section.
To avoid unnecessary drawing repetition, only a small number of holes has been shown.



Equipment for Measuring

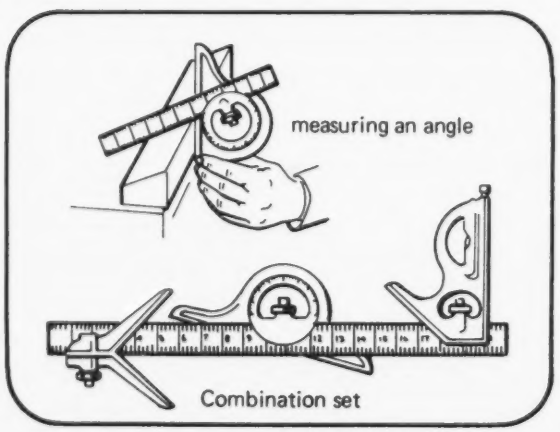
Steel Rule
By using a steel rule correctly, parallax errors are avoided. These are apparent differences in dimensions caused by changing the position of the point of observation.



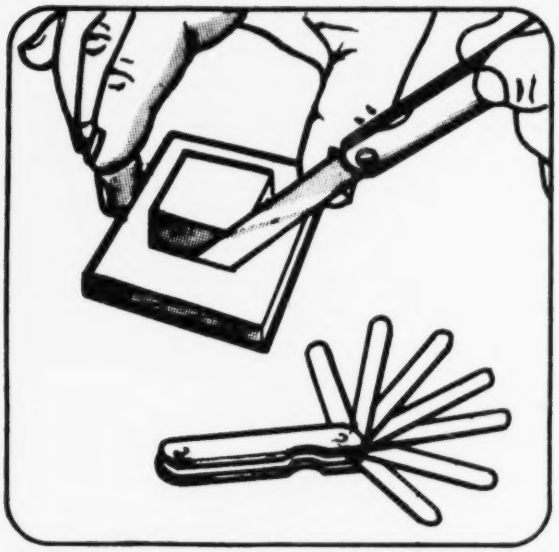
Inside and Outside Calipers
Calipers are used for measuring or comparing distances and sizes.

Outside Calipers
The legs of outside calipers are curved, and turn inwards towards the points. They are used for outside measurements.

Inside Calipers
The legs of inside calipers are straight, and turn outwards towards the points. They are used for inside measurements.



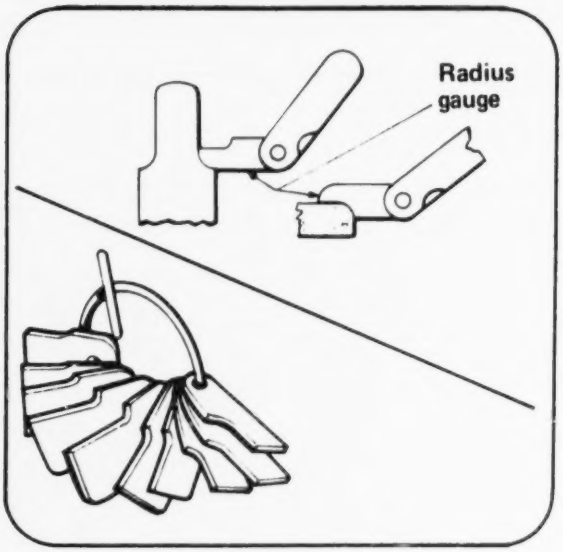
Combination Sets
A combination set is three tools in one. There is a rule and protractor head, a square head, and a centre head. The protractor head is used to measure any angle up to 180°. The square head can be used as a square, a mitre, or a height and depth gauge. The centre head is used for locating centres, of, for example, a shaft or bar.



Gauges

Feeler gauges
Manufactured from accurately rolled shims, feeler gauges are used to measure very small gaps. The shims are grouped together in a set of varying thicknesses and allow for measurement of any gap size below 0.050" or 1.25 mm by positioning two or sometimes three shims together.

Always wipe feeler gauges with a clean cloth before and after use. Dirt and grease will cause a false reading.

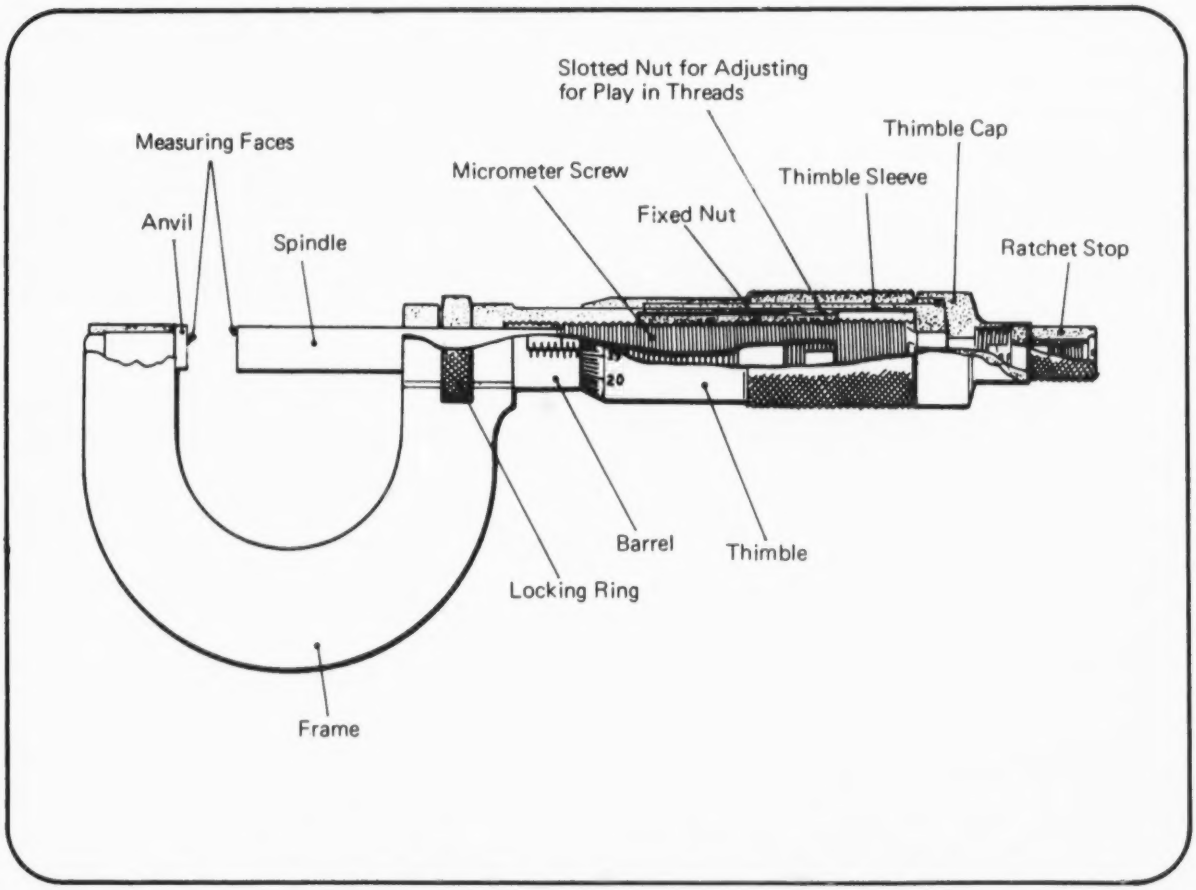


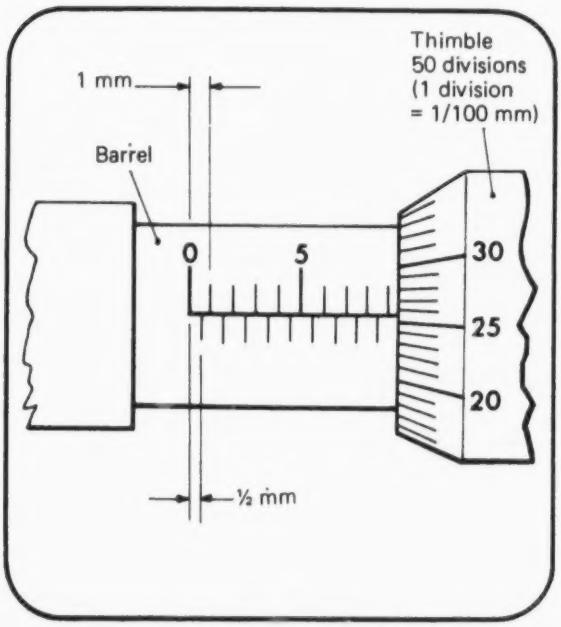
Radius gauges
A radius gauge is used to compare the profile of a radius with one that has been accurately machined.

A piece of tool steel is cut with both an inside and outside radius of a stated size and grouped with others of common fractional or decimal sizes to make a set covering a range of radii in equal spaced steps.

The Micrometer

The micrometer is an instrument for measuring and comparing thicknesses.





The Micrometer (Metric)

The pitch of the screw in a metric micrometer is ½ millimetre (mm), thus the spindle moves ½ millimetre (mm) for each complete revolution of the thimble.

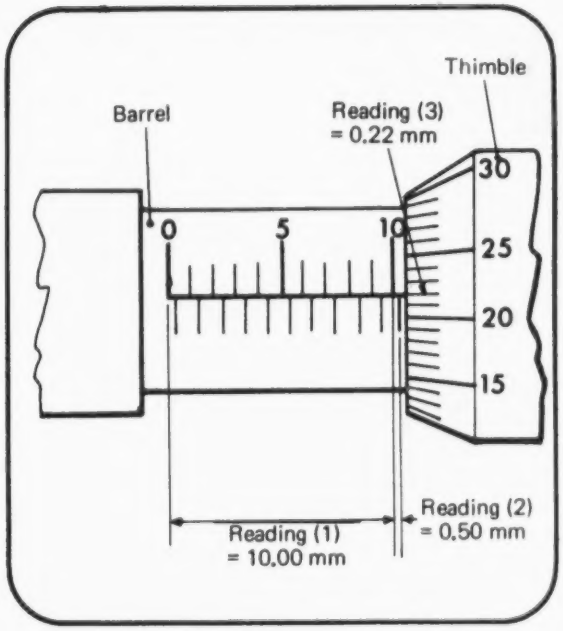
The bevelled edge of the thimble is divided into 50 parts, thus each graduation represents 1/50th of ½ mm which equals 1/100 mm (0.01 mm).

The barrel is graduated in mm above the axial line and in ½ mm below this line.

How to read a micrometer (Metric)
1. Read the number of whole mm divisions visible on the barrel (above the axial line) and add to:

2. The number of additional ½ mm divisions visible on the barrel (below the axial line) and add to:

3. The line on the thimble which coincides with the axial line on the barrel.



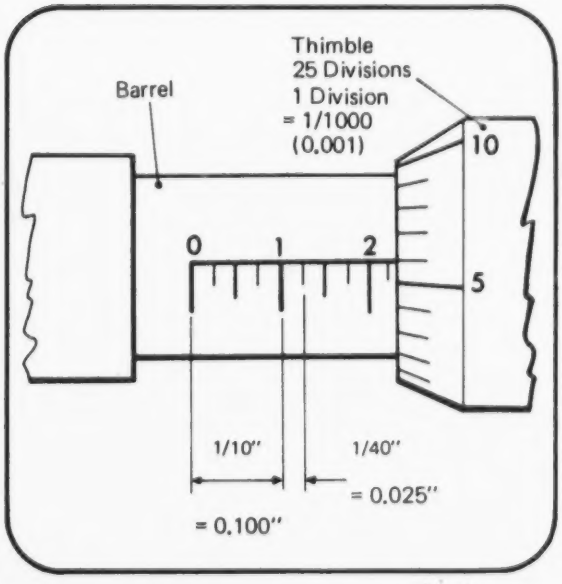
Example:

(1) Whole mm lines (upper) visible on barrel . . . . . 10 = 10.00 mm

(2) Additional ½ mm line (lower) visible on barrel . . . . . 1 = 0.50 mm

(3) Line on thimble which coincides with axial line on barrel . . . . . 22 = 0.22 mm

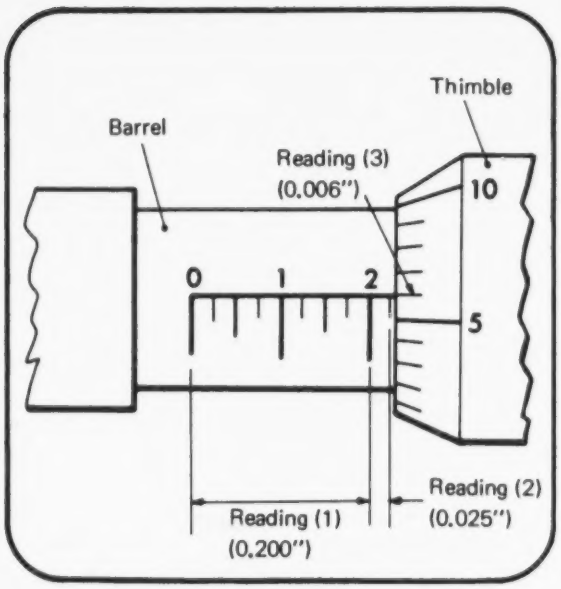
Total reading = 10.72 mm



The Micrometer (Imperial)
The pitch of the screw in an Imperial Micrometer is 1/40th inch = 0.025 inch. Thus for one complete revolution of the thimble the spindle moves 0.025 inch.

The bevelled edge of the thimble is divided into 25 parts, thus each division represents 1/25th of 0.025 which equals 0.001 (one thousandth) inch.

Every fourth vertical division on the barrel represents 0.100 inch (1/10th) and is marked 1, 2, 3 etc.



How to read a micrometer (Imperial)

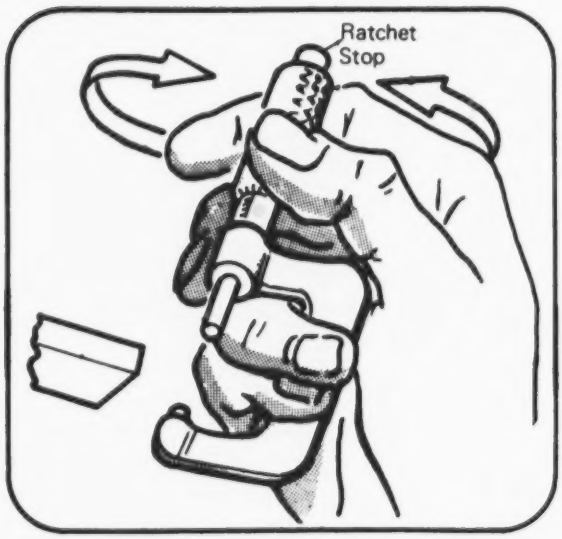
1. Read the number of longer vertical divisions visible on the barrel (1/10ths = 0.100) and add to:

2. The number of smaller divisions visible on the barrel (1/40th = 0.025) and add to:

3. The line on the thimble which coincides with the axial line on the barrel.

Example:

(1) Highest figure visible on barrel	2 = 0.200"
+	
(2) Lines visible between number 2 and thimble edge	1 = 0.025"
+	
(3) Line on thimble which coincides with axial line on barrel	6 = 0.006"
Total Reading =	0.231"

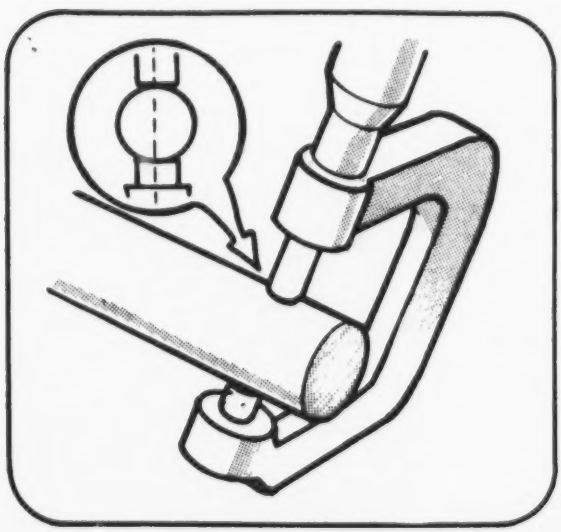


Operate the smaller size micrometers with one hand allowing the other hand free to hold the workpiece.

1. Hold the frame in the palm of the hand by gripping with the second, third and fourth fingers.

2. Rotate the thimble by the ratchet stop, if one is fitted, using the thumb and first finger. This gives uniform pressure and ensures consistent readings.

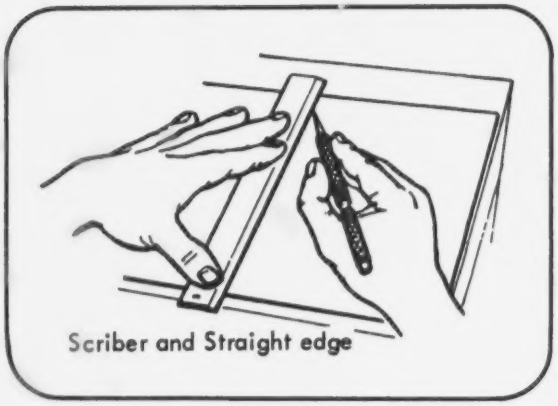
If a ratchet stop is not fitted rotate the thimble, taking care not to use undue force which can cause excessive wear of the screw threads and damage to the measuring faces. It can also cause "springing" of the faces giving inaccurate readings.



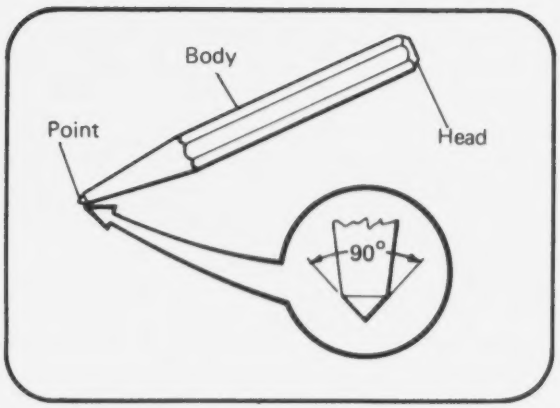
To measure round objects roll the object over the anvil to ensure that the measurement is recorded at the largest diameter.

Measuring and Marking Out

Marking-Out Equipment

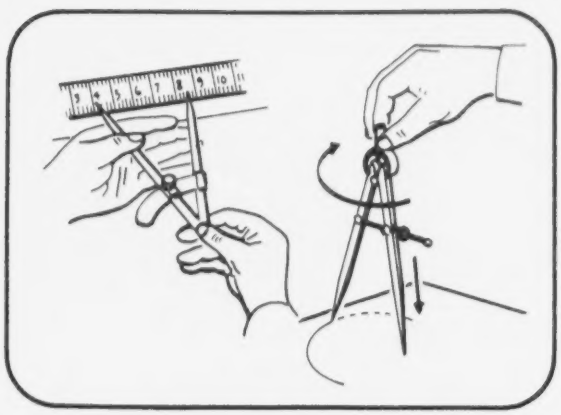

Scriber and Straight edge

Scriber and Straight Edge
The correct method of marking work, using a steel scriber and straight edge, is shown in the illustration.

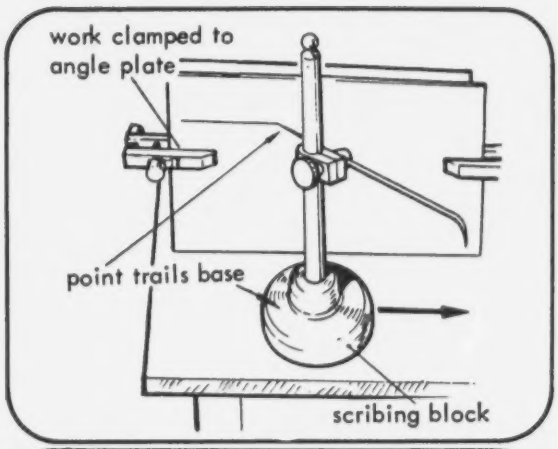


Centre Punch
The centre punch is used for making small indentations or "dots" in metal surfaces, when struck with a light blow from a hammer. Dots are used to mark lines more clearly or to provide starting centres for drills.

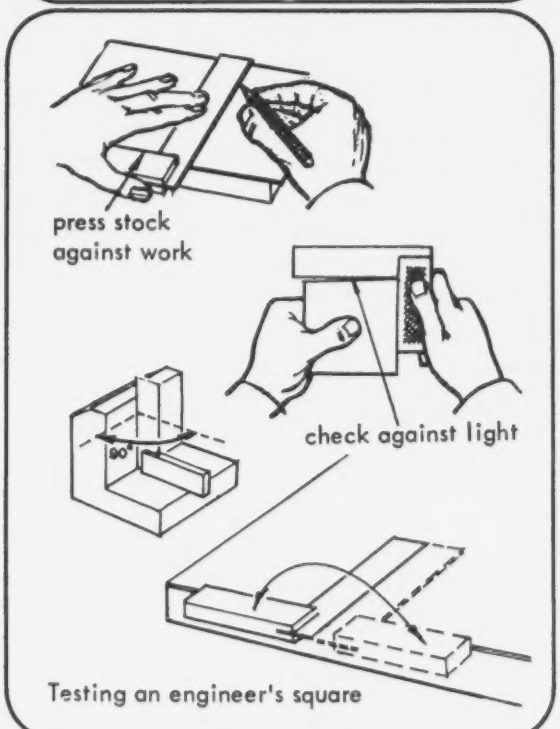
Dot punch (not illustrated)
This has the general shape of a centre punch but the point is ground to an included angle of 60°.



Dividers
Dividers are used for scribing circles and marking off lengths and arcs. They should be set to the engraved lines of the rule.



Scribing Block
A line parallel to an edge can be scribed with a scribing block. The workpiece should be held firmly. The point of the scriber should trail the base, otherwise it will tend to dig into the work.

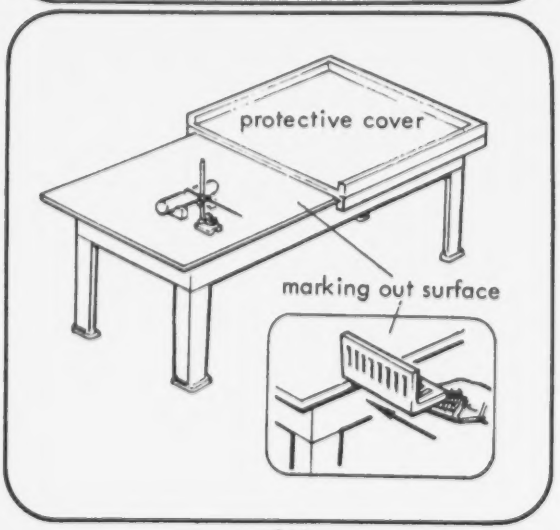


Testing an engineer's square

Engineer's Square

Using the engineer's square
The inside of the blade and stock is used to check a face at 90° to a datum surface.
To test an internal right angle, the stock should be held firmly on the datum surface with the blade at right angles to the other surface.

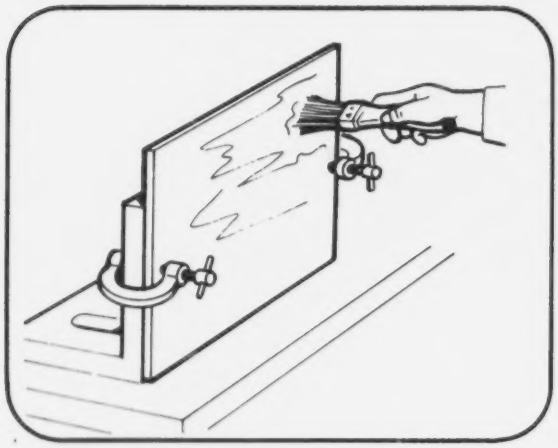
Testing engineer's squares
Squares can be tested against a master square, or by scribing a line and, working from the same base, turning the square over. Blade parallelism is tested with a micrometer.



Marking Out Table
A marking out table with rigid legs and a cast iron top, planed flat, is essential for marking out. The surface must be kept in good condition and should be protected when not in use. Care should be taken in placing tools on the table. Nothing which could damage the surface should be put on the table and tools must not be dropped on it.

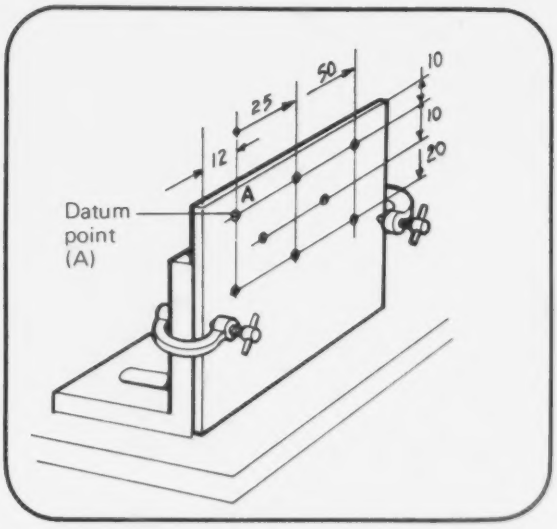
Marking-Out Procedures

Preparation of Surfaces
Surfaces may be brushed with a suitable marking out medium. This helps to show up a line very clearly.



Marking-out Mediums
(a) Spirit Blue or Copper Sulphate – used for machined surfaces.

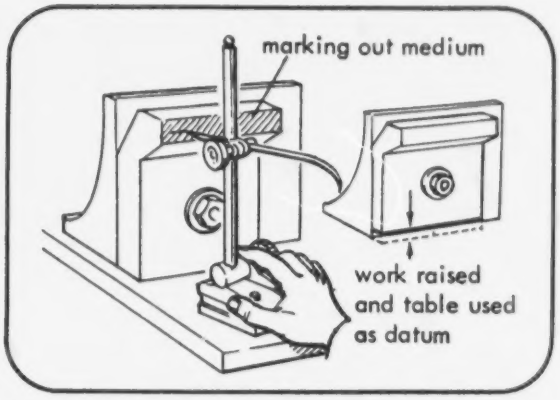
(b) Chalk or Whitewash – used on rough faces of castings.



Marking-out
In marking out, a convenient starting point (datum) must be found, applicable to the particular job.

If a datum face is not obtainable, marking out must be started from a datum line or point.

Using the centre of a hole as a datum point
Hole (A) is the datum.
The remaining holes will be marked out from the centre of hole (A).

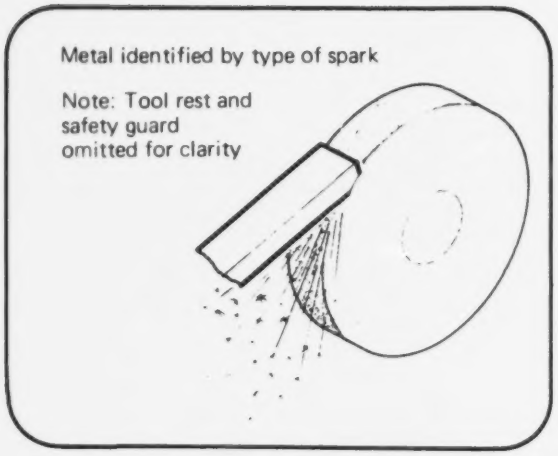


Using the marking out table as a datum face.

Materials

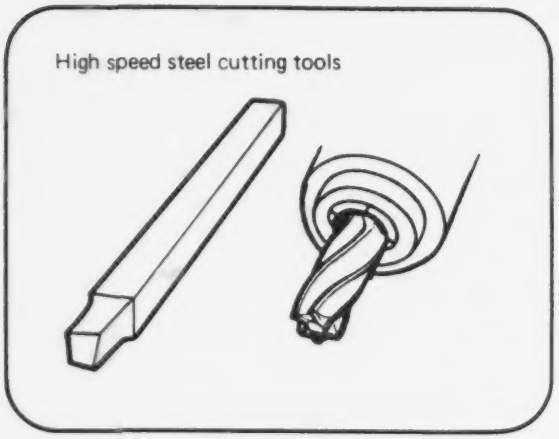
This section provides brief descriptions and some uses of types of metals and non metallic materials which you will meet or use.

Metals



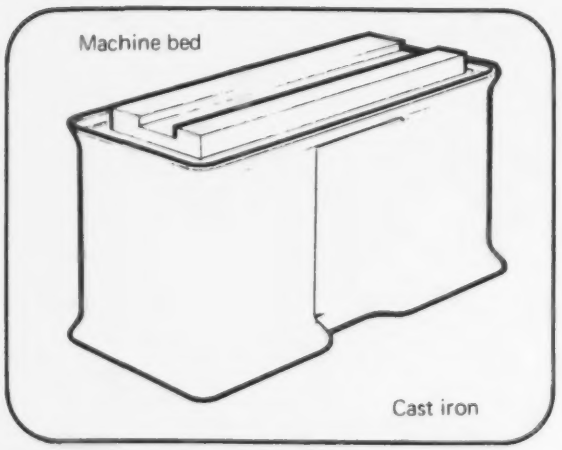
Mild Steel
Mild steel has a low carbon content. It can be recognised by the spark test, i.e. when ground on an emery wheel a stream of long white sparks is produced. Mild steel is used for structural work and general purposes, being relatively cheap and easily machined.

Medium Carbon Steel
Medium carbon steel is harder than mild steel. As the carbon content of the steel increases, the sparks in the spark test occasionally burst, so that medium carbon steel produces a mixture of long white streaks and redder sparks. Typical objects made of medium carbon steel are agricultural implements, springs, locomotive tyres, hammers, shear blades.

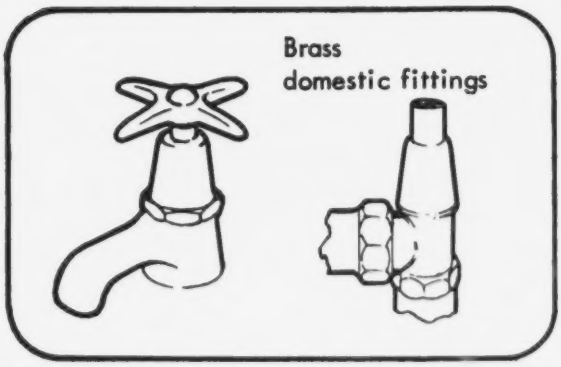


High Carbon Steel
High carbon steel is hard, and it can be recognised in the spark test by the shower of bursting sparks produced by the high carbon content. It is used for engineering tools such as cold chisels, drills, taps, reamers, dies and scrapers.

Alloys of Steel
The properties of steel can be improved by the addition of other elements, such as tungsten. Alloy steels have great strength and toughness, and can be used at high temperatures. They are used for metal cutting tools.

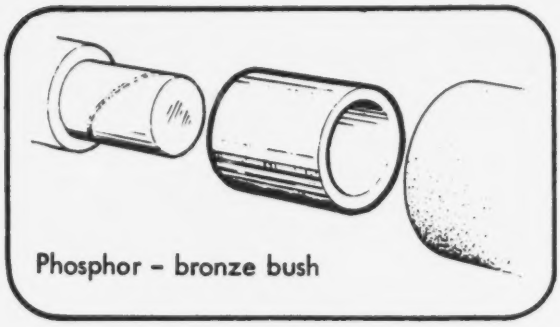


Cast Iron
Cast iron has an open texture, is brittle and will not bend. It withstands compression well and is self lubricating, easily cast, and hard wearing. The surface of castings is often hardened by chilling in a sand mould. Typical objects of cast iron include surface tables, machine beds and fire bars.



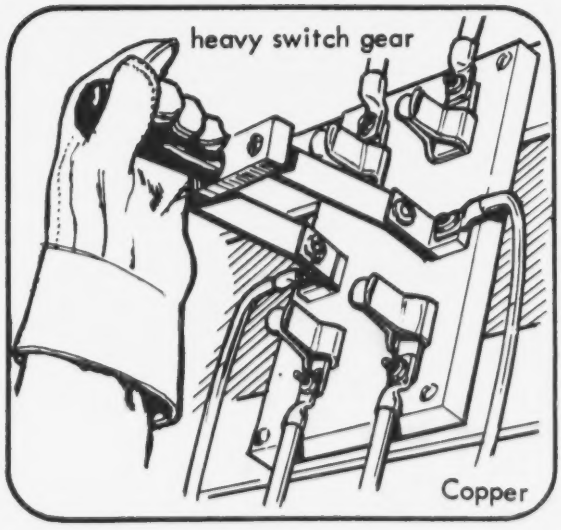
Brass
Brass is an alloy of copper and zinc. It is highly resistant to corrosion but tarnishes easily. It is harder than copper, it casts well, and is easily machined. It can be soldered and brazed easily and is a good conductor of electricity and heat.

Bronze
The bronzes are alloys of copper and tin. They wear well, resist corrosion, and have good machining properties.

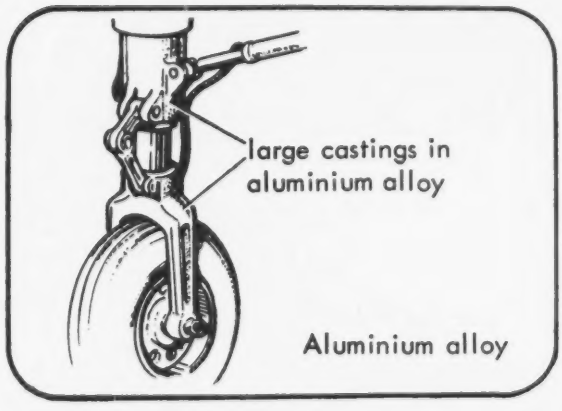


Phosphor Bronze

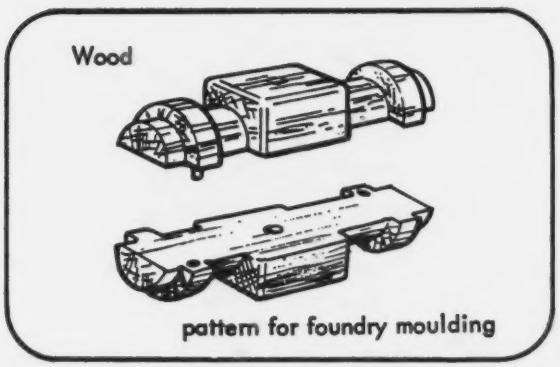
Phosphor bronze is used for parts which must be resistant to wear and corrosion. It is used for bearings, bushes and gears.



Copper
Copper is soft and easily worked when pure. It has high corrosion resisting properties and conducts electricity very readily. It can be formed into sheet or plate, wire, rods and tubes. It is used for soldering iron bits, electrical wire, bus bars, domestic hot water tanks and modern plumbing.



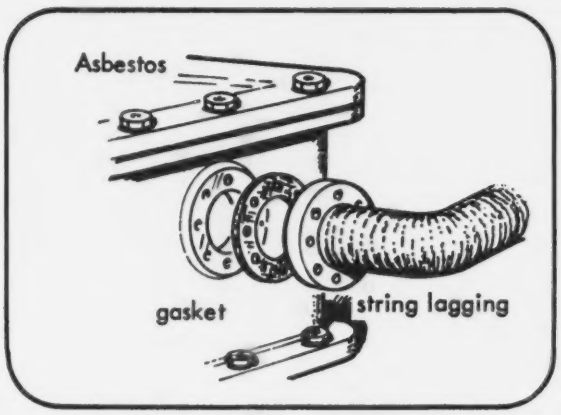
Aluminium
Aluminium is a soft light metal. It is a good heat conductor, and an excellent electrical conductor, being used with a steel core for overhead cables. Aluminium alloys can have great strengths and still be light in weight.



Non-Metallic Materials

Wood

Wood has a wide and varied application in engineering ranging from tool handles to patterns for foundry work or full size mock-up models of equipment to be built. Whatever it is used for, wood must be well seasoned to prevent warping.

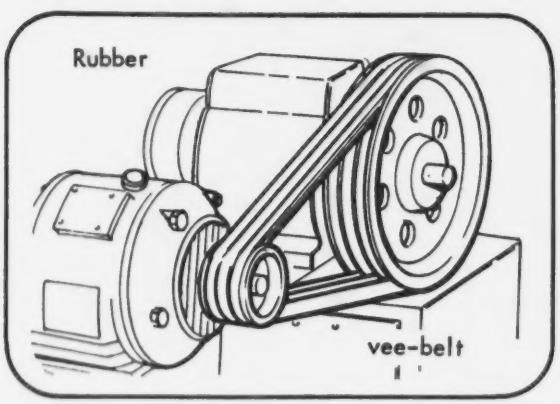


Asbestos

Asbestos is used in many ways for engineering. Sheets of hard asbestos for roofing and partitioning; soft asbestos for heat insulation and fireproofing; for joining and gaskets; in string form for lagging and with the addition of graphite as gland packing for valves and pumps.

Safety

Asbestos is an extremely hazardous material which should only be touched by adequately protected persons.



Rubber

Rubber, after being processed, has a wide range of engineering applications, the most usual being conveyor belting and power transmission belting.

Plastics

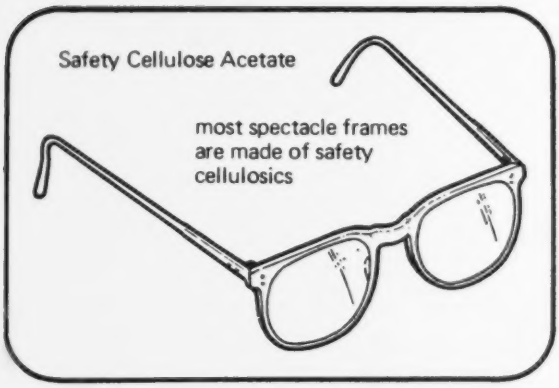
Plastics are man-made materials having widely differing properties and uses.
Thermoplastic material softens under heat and pressure.
Thermosetting material changes its shape permanently and it cannot be remoulded.
Plastics are used for linings and coverings, vessels, electrical insulators, adhesives, thermal and acoustic insulators, packages, laminated boards and rods, low friction bearings and quiet running gears.

Safety

Plastic materials vary widely in their behaviour. Always make sure you know the safe working method.

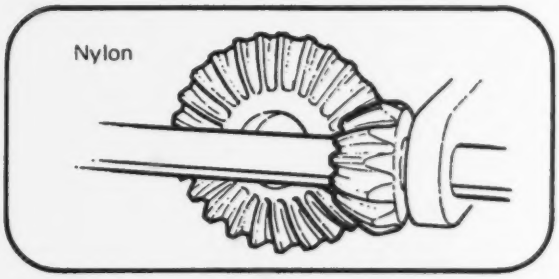
Working with Plastics

High speed steel or carbide tipped tools should be used for machining plastics. Cutting speeds should be high and depth of cut shallow. Cutter and materials should be well cooled. Tools must be sharp and ground to give adequate chip clearance.

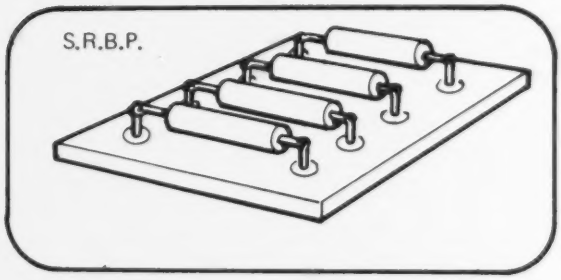


Types of Plastic

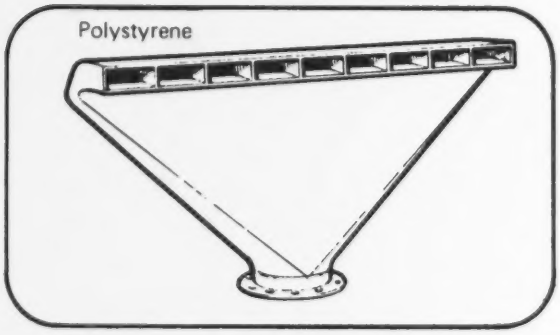
Safety Cellulose Acetate
This is used for moulded and sheet fabricated articles.



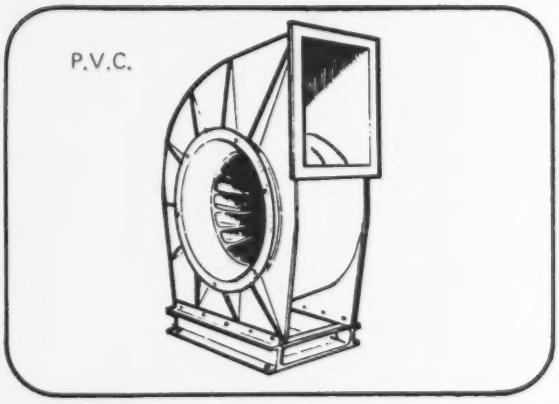
Nylon
Nylon is used for coil formers, low friction bearings and quiet running gears.



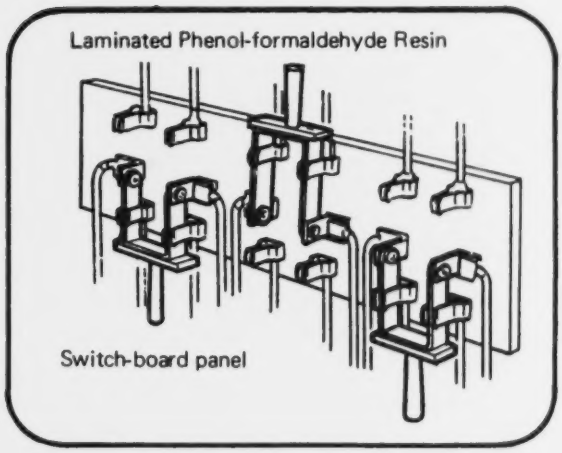
S.R.B.P.
Synthetic Resin Bonded Paper or Fabric (S.R.B.P. or F.) (pheno-formaldehyde resins)
This consists of layers of treated paper or fabric compressed to form a hard smooth board and is available in many grades and forms.
Sheets are used for terminal boards, barriers and panels. In tube form it is used for coil formers, spacers and shrouds.



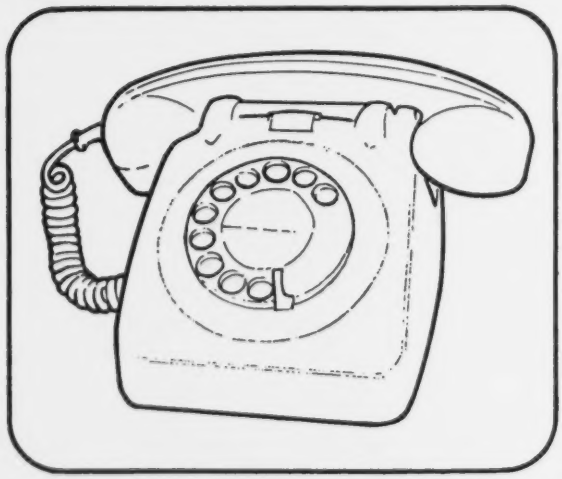
Polystyrene
Polystyrene is used for non-corrosive vats, funnels, pipes, and when expanded, for thermal and acoustic insulations.



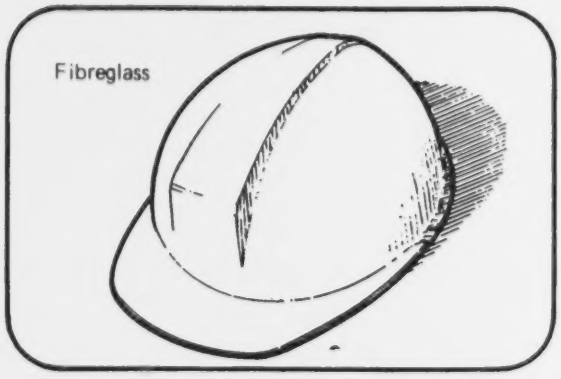
P.V.C. (Polyvinyl Chloride)
P.V.C. is used for corrosion resistant pipes, tanks and waterproof sheeting.



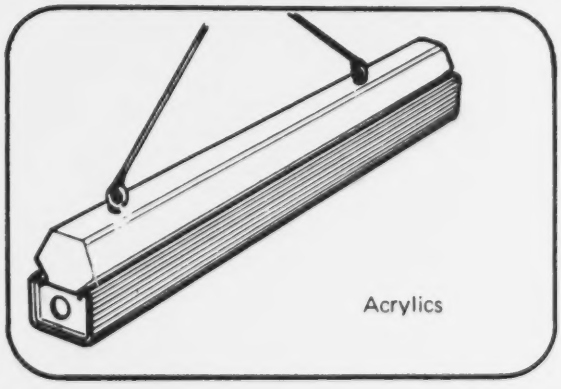
Laminated Phenol-formaldehyde Resins
These are used for high frequency insulation and switchboard panels.



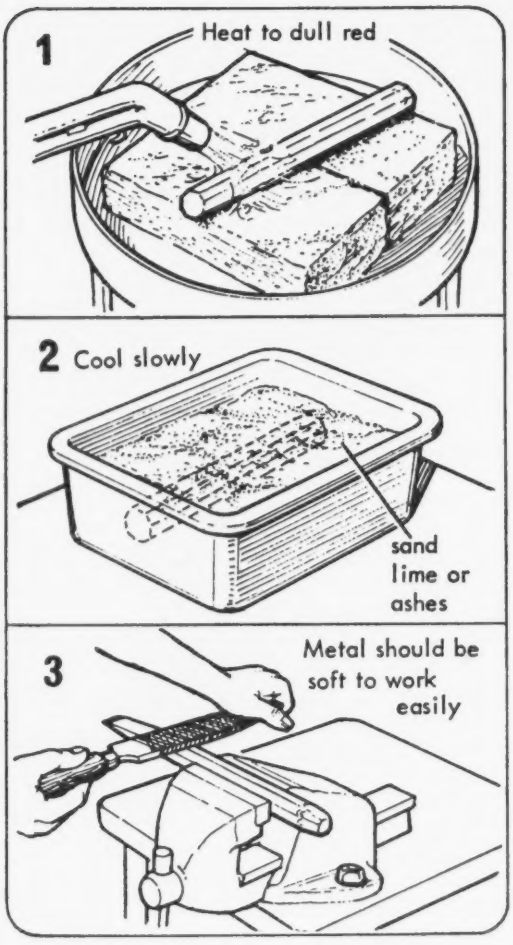
ABS (Acrylonitrile-Butadiene-Styrene)
Used for vacuum formed containers, telephone handsets, office equipment cabinets.



Fibreglass
Fibreglass reinforced resins are used for high temperature insulations, thermal and acoustic insulations and for fire-proof fabrics.



Acrylics (polymethylmethacrylate)
Used for aircraft canopies and windows, lighting fittings and transparent guards.



Heat Treatment

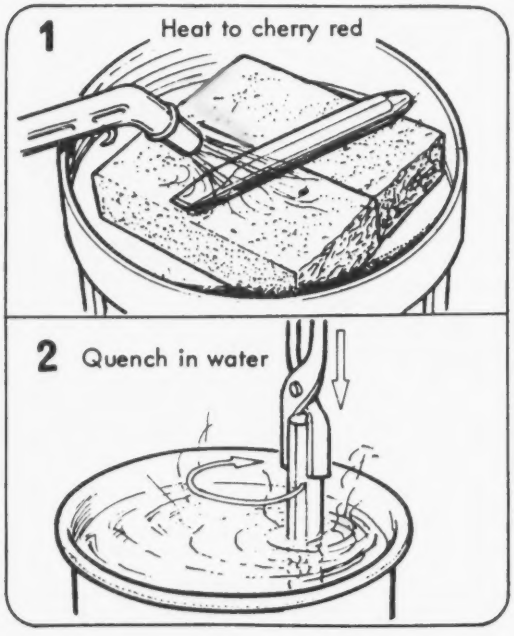
Heat treatment is a term used to describe a process of changing the properties of a metal by careful heating and cooling. For hand tools and small workpieces, the work can be done in the workshop forge.

Annealing

This process makes a metal soft and workable. The illustrations show the process of annealing a bar in order to make a chisel.

1. The bar is heated.
2. The hot bar is cooled slowly in sand.
3. The bar is worked to shape.

Metals can become hard when they are struck repeatedly – this is called "work hardening". Work hardened metals are restored to their original state by annealing.

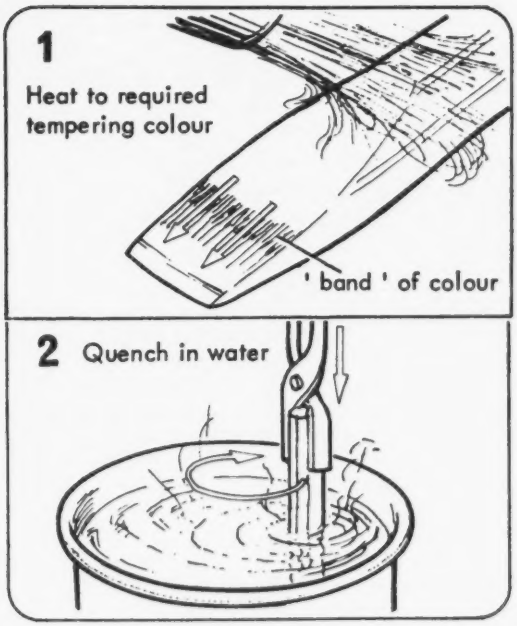


Hardening

This chisel shape needs to be hard in order to cut.
The diagrams show the process of hardening by:

1. Heating to cherry red.
2. Quenching in water.

The workpiece should be plunged vertically into the water, and moved rapidly to ensure uniform cooling and prevent cracking. When quenching jobs of irregular shape, the larger end should always be quenched first.



Tempering
When metal is hardened, it sometimes becomes brittle. This can be reduced by tempering.

The part is cleaned to bare metal. (This ensures easy recognition of colour changes, when the metal is heated.)

1. Heat the metal. The first colour to appear is yellow, followed by brown and finally blue.

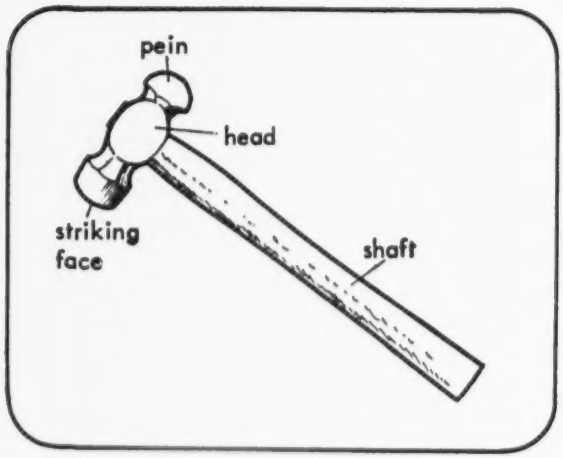
2. Quench the metal in water immediately the right colour is reached.

Quenching Colours are:

Colour	Type of Article
Pale Straw	Scrapers and scribers
Deep Straw	Drills
Yellow-brown	Punches, pipe-cutters
Purple-brown	Rivet snaps, plane irons
Purple	Axes, press tools
Deep Purple	Cold chisels
Deep Blue	Springs

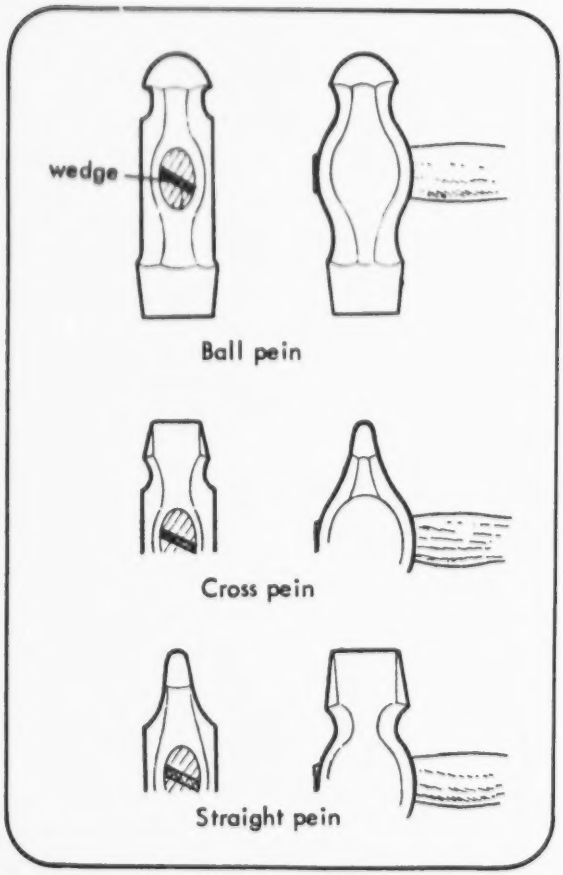
Hand Hammers

A hammer consists of a steel head and a wooden shaft. The striking face and the pein are hardened and tempered. The shaft is of straight-grained hickory or ash. The wood should be free of knots and be well seasoned. The shaft must be of appropriate size for the head. It must fit the head, and be secured with wedges. A hammer with a loose head, a chipped face, or a split shaft must never be used.



Classifying Hammers

A hammer is classified by the shape of its head, and its weight.

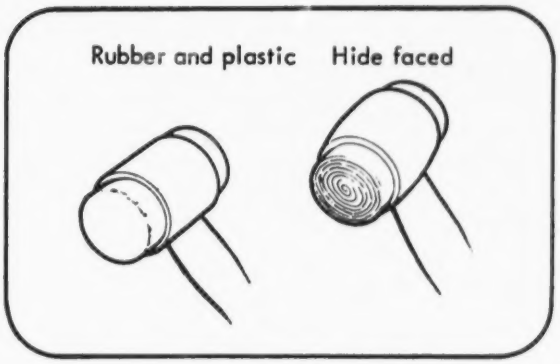


The Shape of the Head

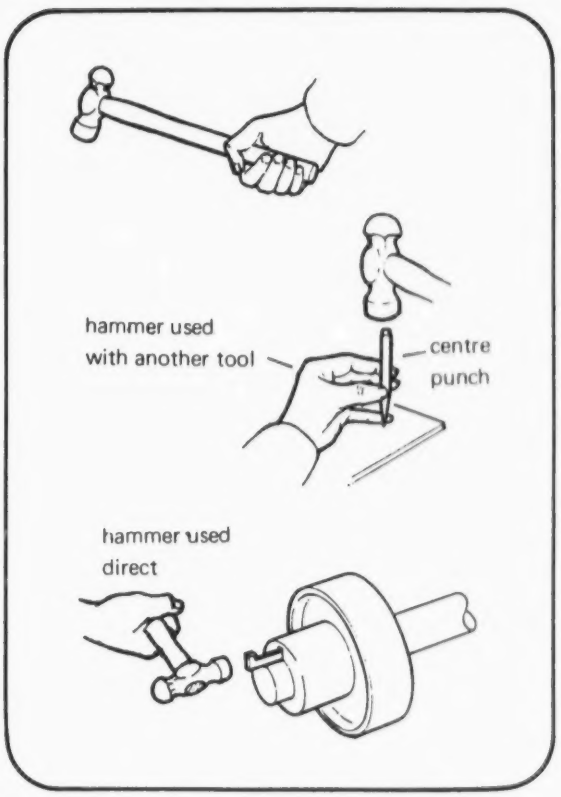
A ball pein hammer is most commonly used. Cross pein and straight pein hammers are used in awkward places where a ball pein could not reach.

The Weight

Hand hammers vary in weight between 0.113 kg and 1.36 kg.



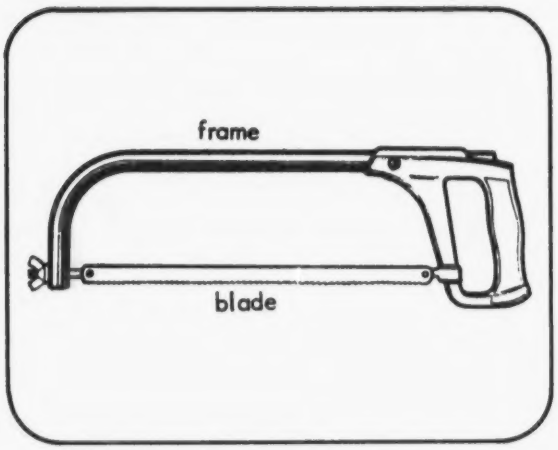
Special Duty Hammers
There are soft hammers made of various materials such as rawhide, copper, brass and lead. These are used when it is necessary to prevent damage to finished surfaces.



Using Hammers
A hammer must be held in a firm grip at the end of the shaft.

It can be used in conjunction with another tool.

It can be used in direct contact with the work.



Hacksaws
A hacksaw consists of a frame, which may be adjustable in length, and a blade. The blade fits into the frame with the teeth pointing away from the handle.

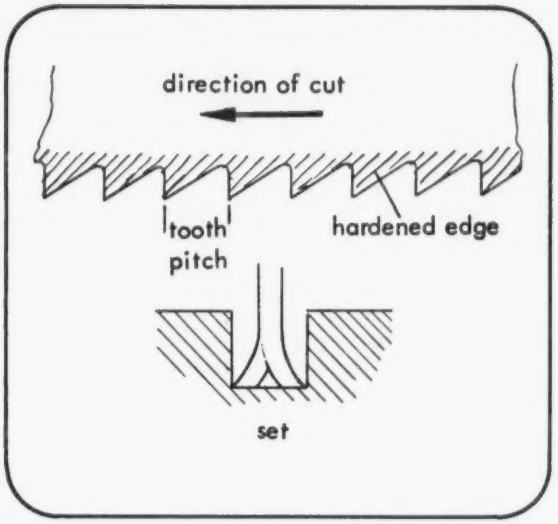
The teeth are set so that the blade makes a cut wider than itself. The blade must be at the correct tension.

Faults to check before use:

(a) The blade must not be twisted.

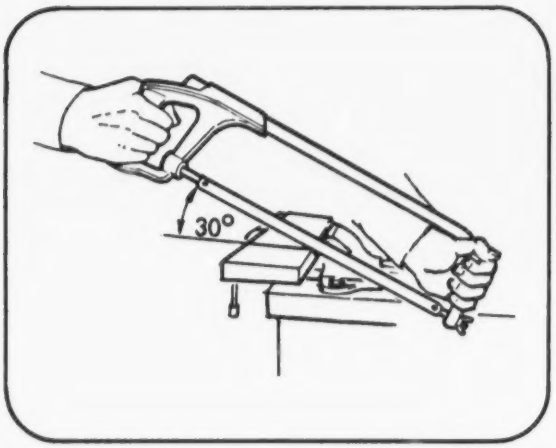
(b) There must be no blunt or broken teeth. The blade must not be discoloured, as this indicates that it is softer than it should be.

(c) The teeth must be facing the direction of cut. A new blade must not be used in an existing cut.

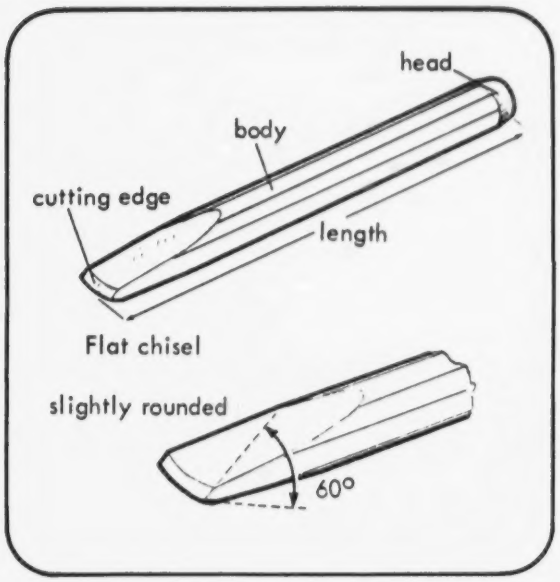


Classifying Blades
A hacksaw blade is classified by the number of teeth per unit length; the length of the blade and the material of which it is made.

A fine blade has 20–30 teeth per 25 mm.
A coarse blade has 14–18 teeth per 25 mm.
A general purpose blade has 16–18 teeth per 25 mm.
Flexible blades are hardened only at the cutting edge. High speed blades are hardened all through.



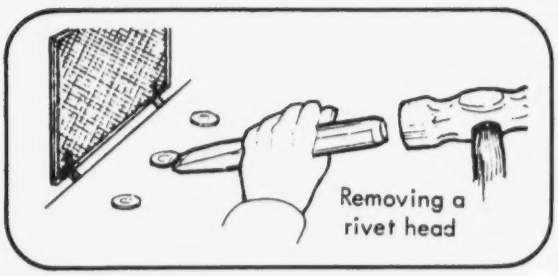
Using a Hacksaw
The angle of the blade to the cut should be 30°. The rate of sawing should be 40–50 strokes per minute. Cutting pressure should be applied only on the forward strokes.



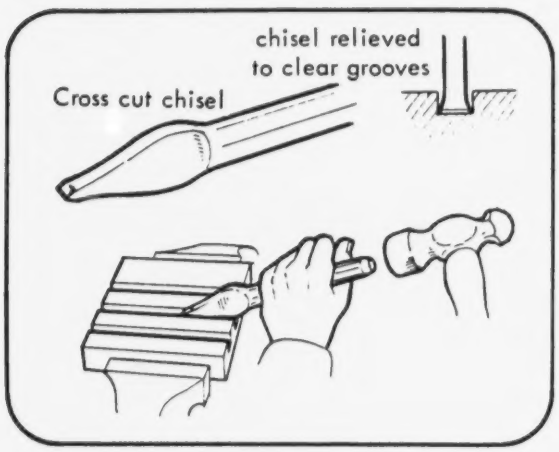
Cold Chisels

Identifying Chisels
Chisels are known by the length and type of cutting edge.

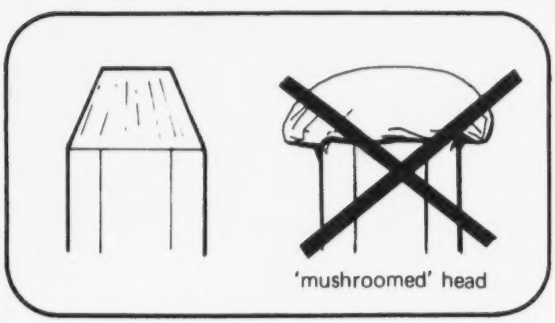
Length
Chisels are made in lengths of usually from 100 mm upwards.



Flat
The flat chisel is a general purpose cutting tool and is the type of chisel most often used. It is used to cut sheet metal, to cut slots in sheet metal, to cut rods and bars, to chip excess metal from large surfaces, and to chip off rivet heads, rusted nuts and holt heads in repair work.



Cross Cut
The cross cut chisel is used to cut parallel grooves, and to break up a large area into sections to be chipped away with a flat chisel. The cutting edge is slightly wider than the rest of the body, to prevent the body from binding in the groove.

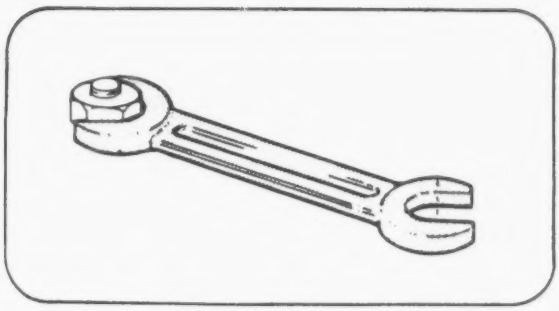


Safety
Cold chisels with "mushroomed" heads should not be used.

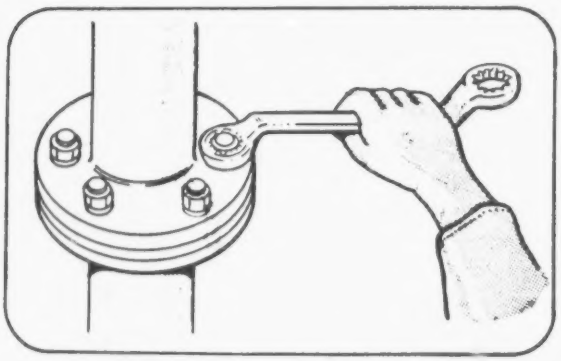
Condition of tools
All tools must be kept clean and maintained in good condition. They should be inspected before use, kept free from grease and cleaned after use. Defective tools are dangerous and must not be used.

Safety
Split file handles, sprung spanners and mushroomed chisel heads are dangerous. Damaged tools must be repaired or discarded.

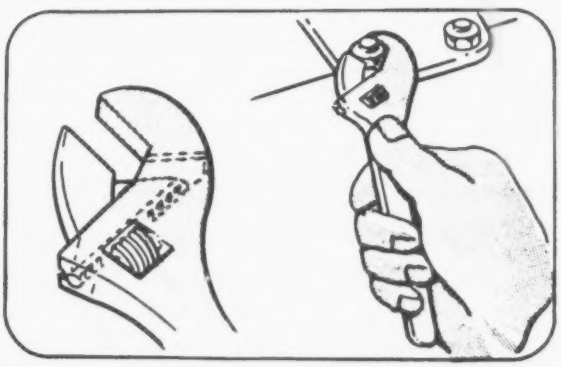
Spanners
Spanners vary considerably in shape to provide ease of operation under differing conditions. They are manufactured from high tensile or alloy steel and are normally identified by the appropriate bolt diameter.
Commonly used scales of measurement are:
Metric (measured in millimetres)
BA (British Association Standard Thread)
BSW (British Standard Whitworth)



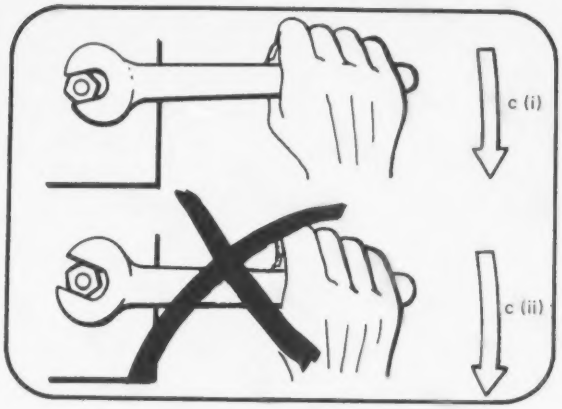
Double open-ended spanner
This is a general purpose tool for use where access to a nut or bolt is not restricted.



Double ended ring spanner
This is gradually superseding the open-ended type as a general purpose tool.
It is easier and more convenient to use when the spanner swing is restricted.



Adjustable spanner
This is a spanner which can be used instead of an open-ended or ring spanner. The jaws are adjustable to accommodate various sizes of nuts within a certain range.



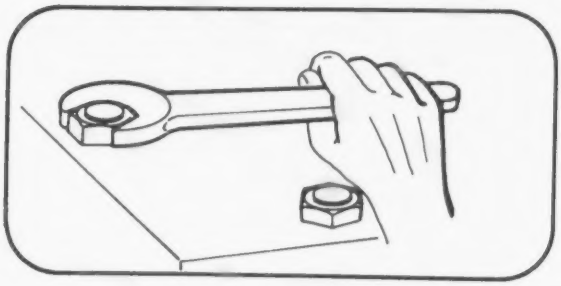
Use of spanners
Accidents with spanners are nearly all caused by the spanner slipping from the nut.

(a) Use the correct size of spanner for the job: Never pack the gap with washers, etc.

(b) Use a rigid-jaw spanner rather than an adjustable type: there is less chance of slipping.

(c)(i) Tighten a nut this way; pressure on the spanner tends to keep the jaws on the nut.

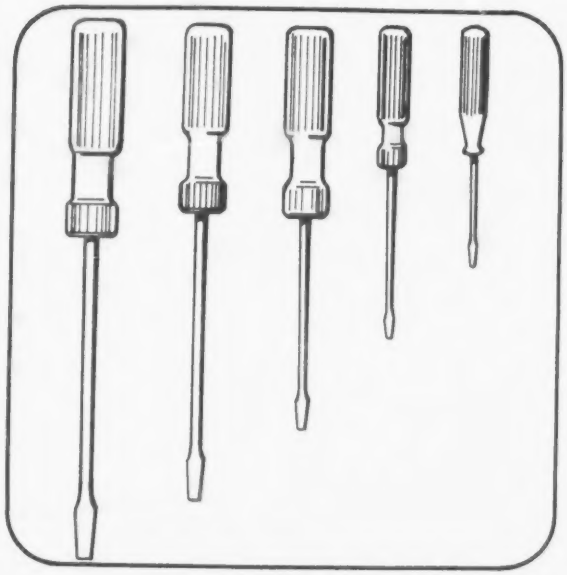
(ii) Used this way the jaws tend to slip off the nut.



(d) Pull toward the body whenever possible; do not obtain extra leverage by improvised extension handles.

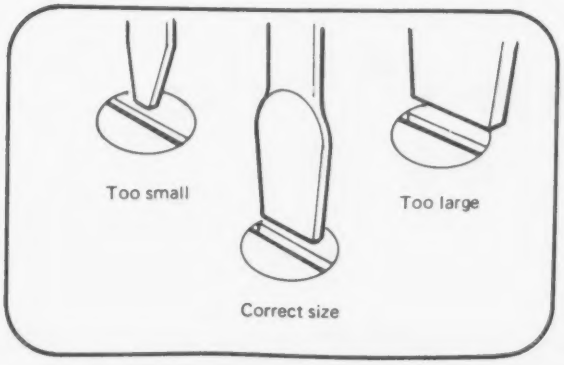
(e) Use a steady pull not a jerky action; do not hit a spanner with a hammer.

(f) Ensure the hands will not strike obstructions if the nut turns unexpectedly.



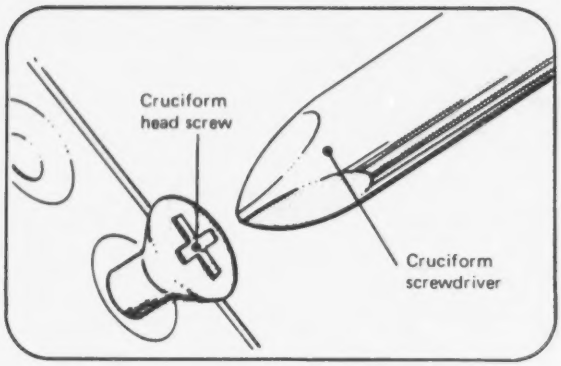
Screwdrivers
Screwdrivers are made in varying lengths and designs.

They are identified by overall length and in some cases by blade width.
Screws are driven by turning the screwdriver handle in the hand, at the same time applying downward pressure.



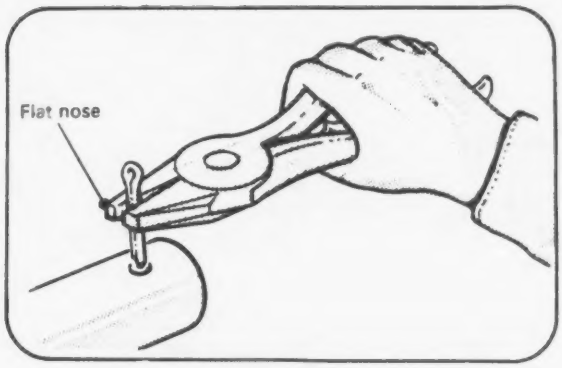
Always use the correct size of blade for the screw head.

The screwdriver blade should fit the width of the screw slot and should not protrude beyond the diameter of the screw head.



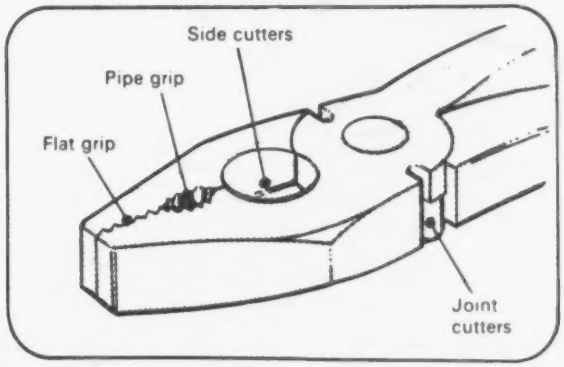
Cruciform Screwdriver
This type of screwdriver must always be used for cruciform recessed-head screws.

It may have a wooden or plastic insulated handle. It is identified by point size.

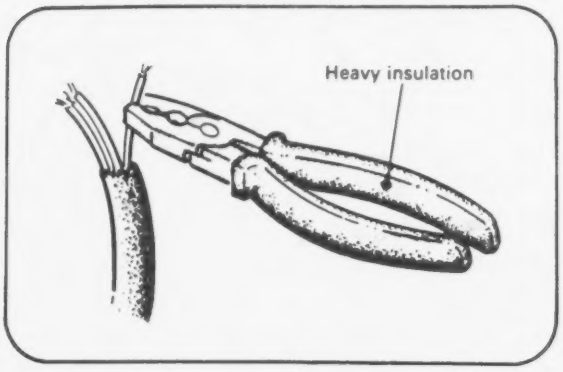


Pliers
Pliers are basically gripping tools, used to grip small components which would otherwise be difficult to hold and control. They are made of cast steel with the jaws hardened and tempered. Classification is by overall length in centimetres.

Flat nose pliers
They are used solely for gripping and holding purposes.

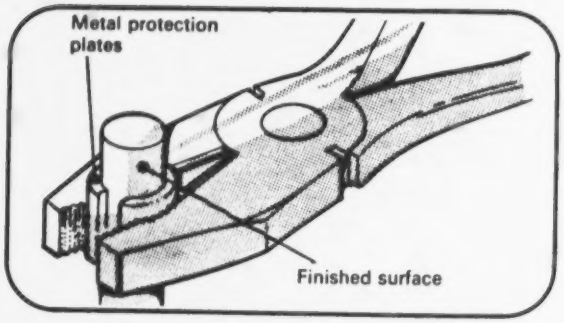


Combination pliers
These are more versatile tools with a greater number of applications. They incorporate side cutters, joint cutters and pipe grip.



Heavy duty electrical pliers
These are similar to the combination pliers with the addition of insulated handles tested to 10 000 volts.

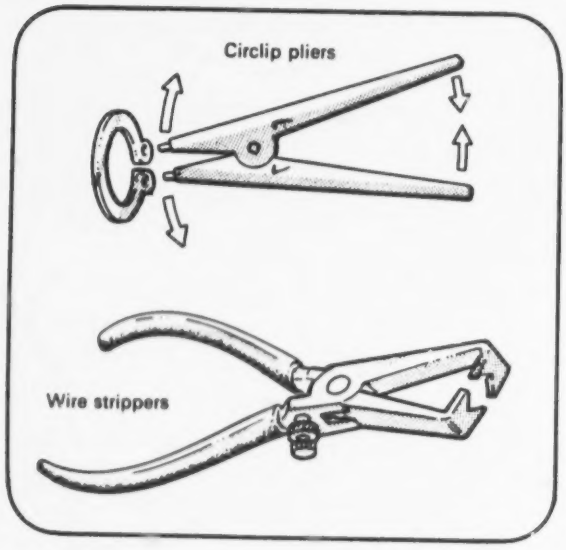
They should always be used when working with electrical components.



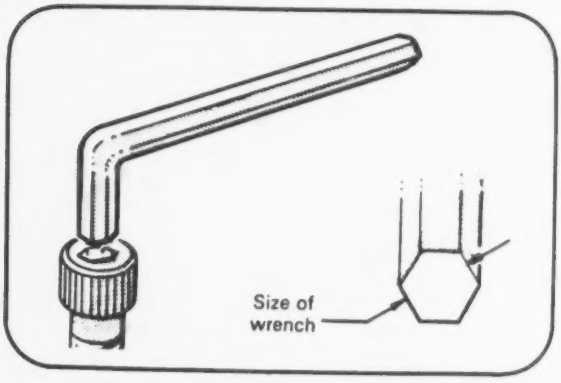
Correct Use of Pliers
Pliers should only be used for holding and gripping, inserting and removing split pins and cutting and tensioning wire.

A finished surface should be protected, otherwise the serrated jaws of the pliers will damage the finish.

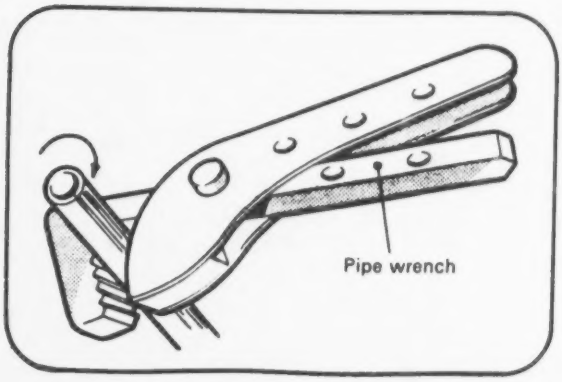
Pliers should never be used to undo or tighten up nuts and bolts.



Miscellaneous types of pliers
There is a range of other types of pliers for special applications e.g. circlip pliers, wire strippers, wire cutters, eyelet pliers and hand crimping tools.



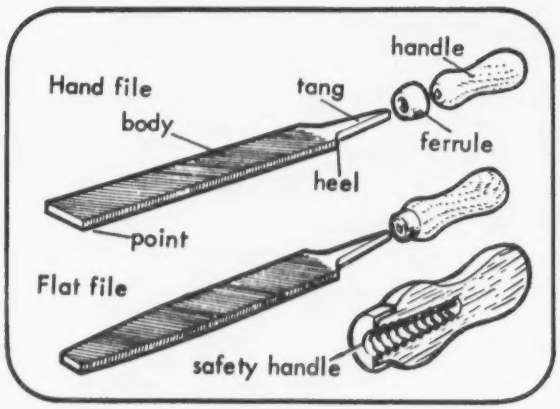
Hexagon socket screw wrench
This is used for hexagon head socket screws. They are identified by their size across the flats.



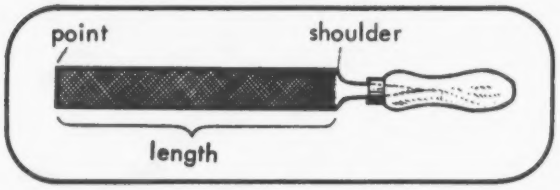
Pipe Wrench
A pipe wrench is designed to tighten its grip on the part being rotated, as it is being used.

It has serrated jaws and so should not be used on surfaces which must not be damaged.

A pipe wrench must not be used to loosen a nut, unless the nut is to be replaced by a new one.



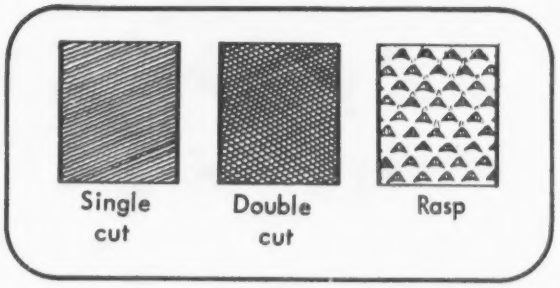
Files
Files are manufactured from hardened steel. Teeth are cut on the body in various patterns and the file is used by hand for the removal of metal.



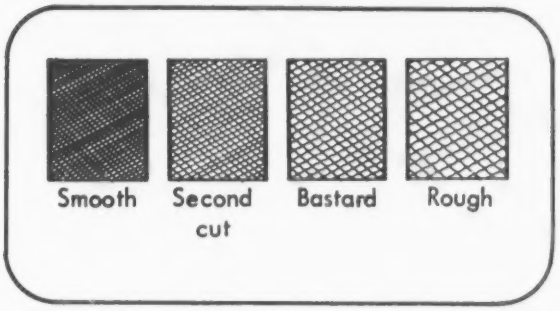
Identifying Files
To identify any particular file it is necessary to know:

the length,
the type of cut,
the grade of cut,
the shape.

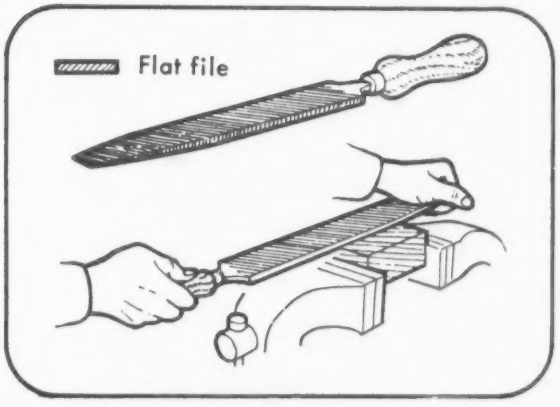
Length
The length of a file is measured from the point to the shoulder.



Type of Cut
The most commonly used cuts are single, double and rasp.

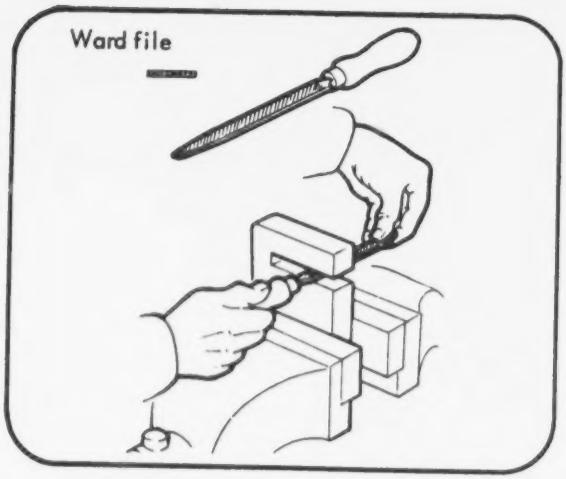


Grade of Cut
Files are cut with teeth of different grades. Those in general use are smooth, second cut, bastard and rough.

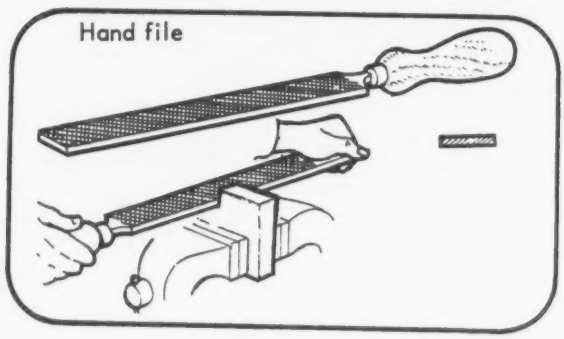


The Shape

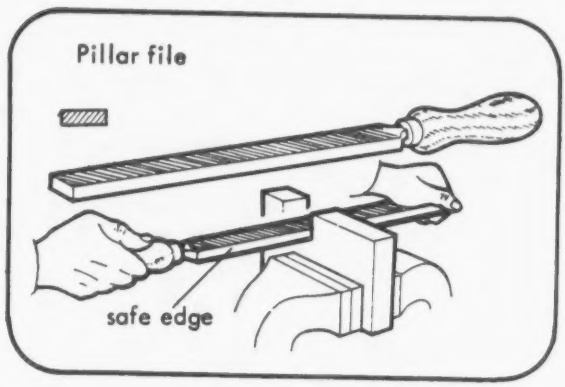
Flat File
A flat file is used for general surfacing work. Both faces are double cut, and both edges are single cut. It is tapered in width and thickness.



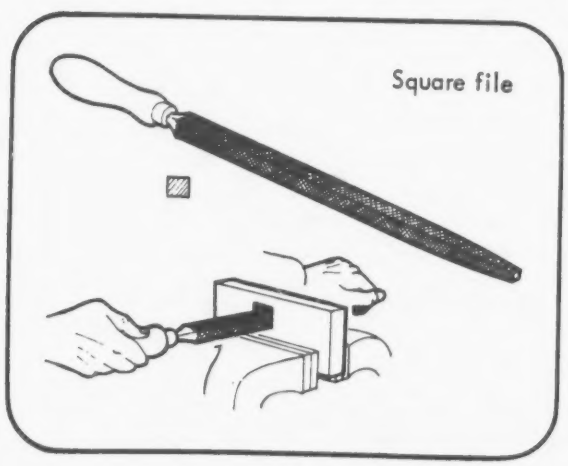
Ward File
A ward file is used for filing in narrow slots. Both faces are double cut, and both edges single cut. It is tapered in width but not in thickness.



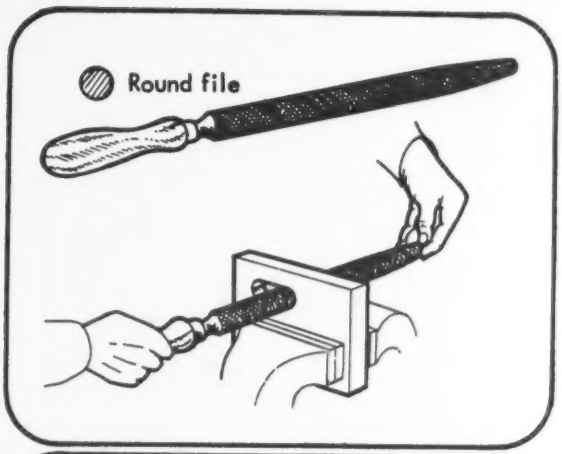
Hand File
A hand file is used for general surfacing work. Both faces are double cut. Either both edges are single cut, or one is uncut to provide a safe edge.



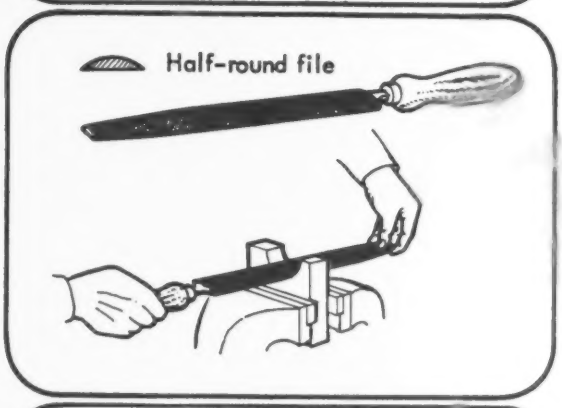
Pillar File
A pillar file is used in narrow slots. Both faces are double cut, and either both edges are single cut, or one is uncut to provide a safe edge.



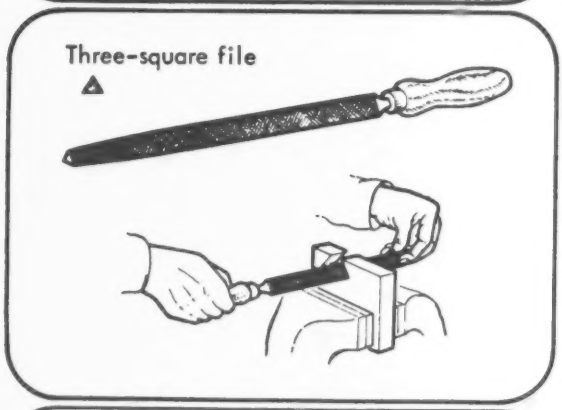
Square File
A square file is used in corners. It is double cut on all sides, and is tapered.



Round File
A round file is used for opening out holes and rounding inside corners. Rough, bastard, second cut and smooth files under six inches in length, are single cut.

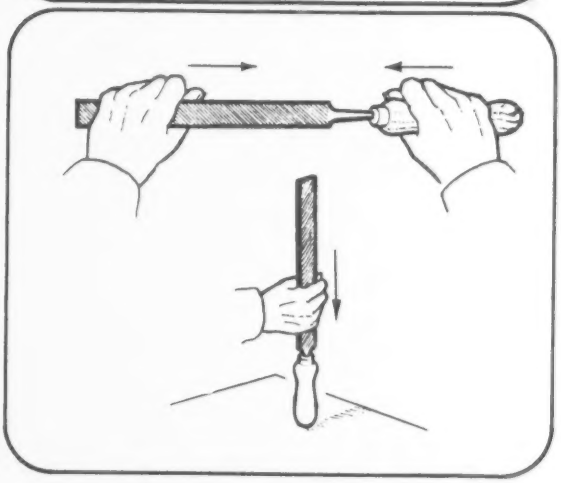


Half Round File
The flat side is used for general work, and the half round side for filing concave surfaces. It is double cut on the flat side. The curved side is single cut, smooth or second cut.



Three Square File
The three square file is used for filing corners between 60^{o} and 90^{o}. It is double cut on all faces.

Safety
A file must always be fitted with a handle. It is extremely dangerous to use a file without a handle as the tang can easily penetrate the hand.



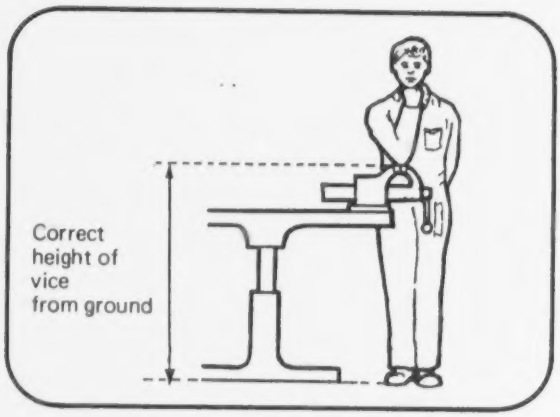
Preparing the File for use
The handle may have a small hole drilled to take the file tang. In this case insert the tang into the hole and gently tap the handle on the bench until the tang is securely fitted into the handle.

If the handle is supplied without a hole, one should be drilled using a drill of appropriate size.

Care should be taken not to split the handle during this operation.

Benches and Vices
The bench should be of rigid construction to provide a sound base for the fitter's vice.

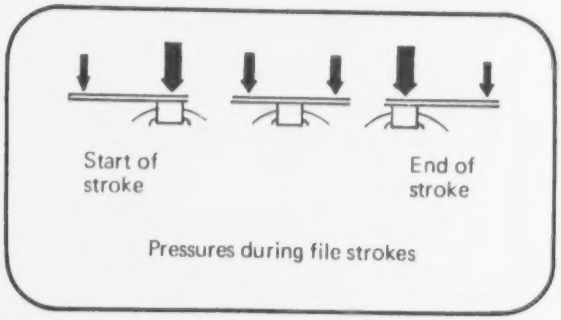
The vice is used to hold the workpiece whilst carrying out such operations as filing, hacksawing, chiselling or scraping.



Vice
The vice holding the work must be at the correct height.

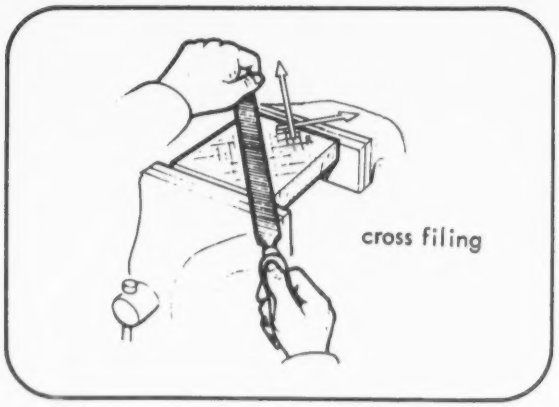
Using Files

Safety
A file must not be used unless fitted with a suitable handle. Ensure that the workpiece is securely held in the vice.

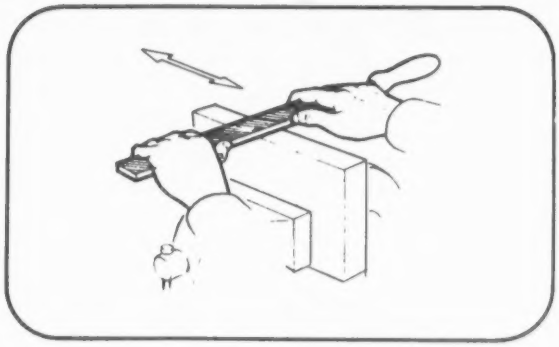


Pressures during file strokes

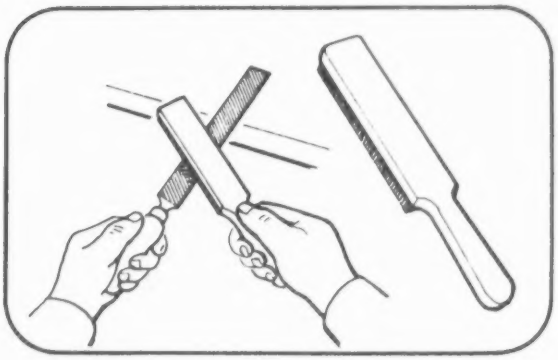
Stance
The correct stance should be adopted. Although the pressures on the file must vary to keep the cut even, the body weight must be distributed evenly to retain balance throughout the stroke.



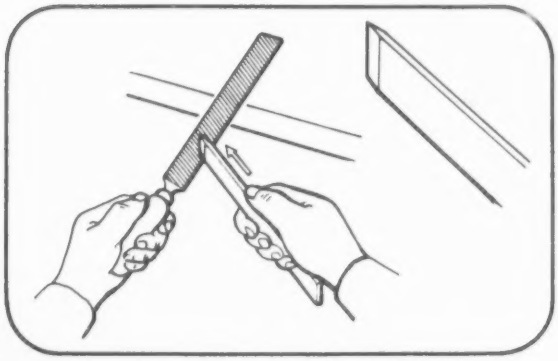
Cross Filing
After filing in one direction, the work is filed again with the strokes at 90° to the original ones.

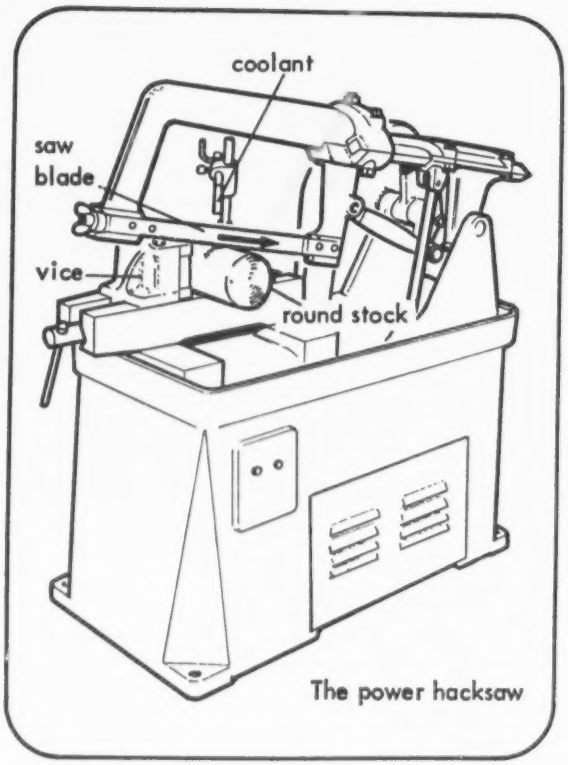


Draw Filing
Once the surface has been filed down almost to size, draw filing can give a fairly accurate and smooth finish. Sometimes particles of material become embedded in the teeth of the file, preventing a smooth finish being achieved. Chalk may be rubbed into the teeth to avoid clogging and so ensure as smooth a finish as possible.



Cleaning Files
A file should be cleaned by brushing with a file card in the direction of the cut, or by means of a strip of thin, soft metal.

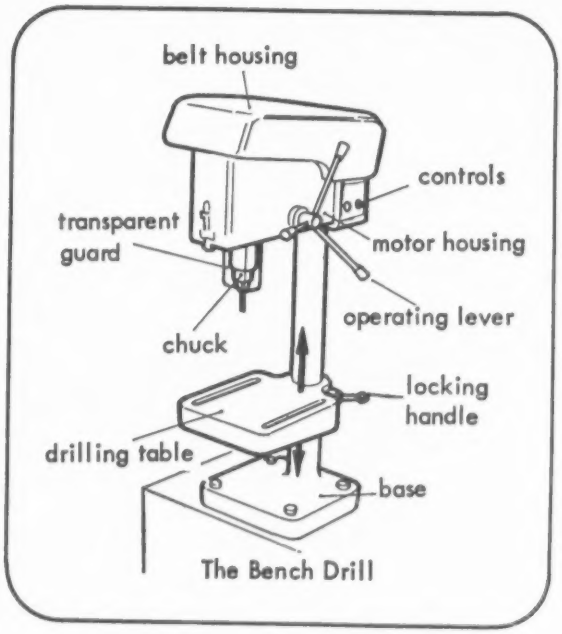




The power hacksaw

Power Driven Hack Saw
These are power-driven saws fitted with a large hack saw blade, and are used for rough cutting of metal bar.

Specification
Sawing capacity, expressed as the maximum diameter of metal bar capable of being cut.

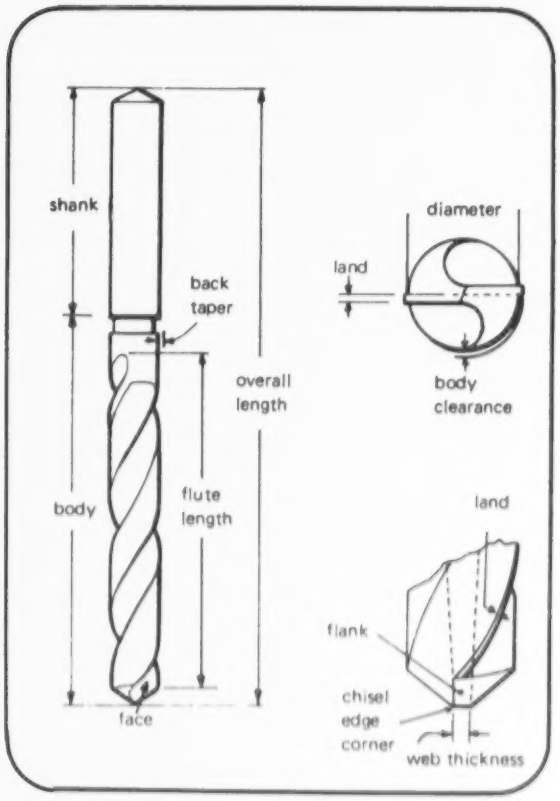


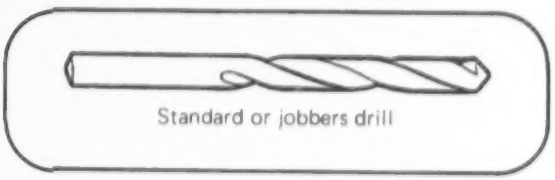
The Bench Drill

Drilling Machines
In a drilling machine the tool is rotated, and is capable of easy movement along the axis of rotation of the tool. There are bench, pillar and radial machines. In each machine the drill is supported and fed vertically into the work.

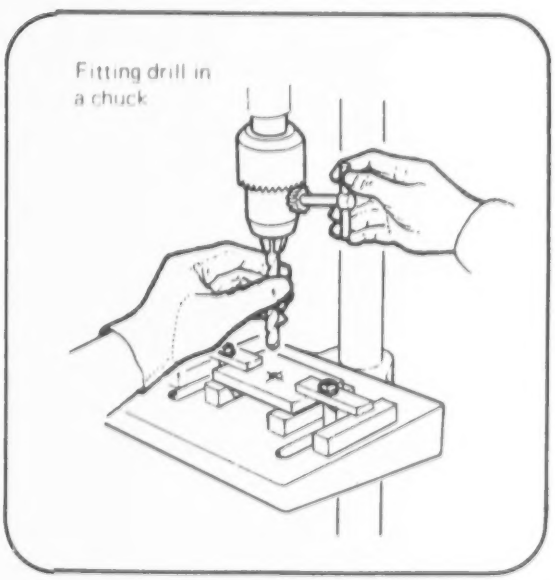
Specifications
Bench drill: the drill capacity; and the range of speeds and feeds.

Cutting Fluids
When using machine tools to cut metal it is necessary to apply a cutting or cooling fluid to lubricate cutting surfaces and to cool the cutter, saw or drill.





Standard or jobbers drill



Fitting drill in a chuck

Drills

Drills are used for producing holes. There are many types of drills designed for varying machining requirements, but the most common are the parallel and taper shank types of varying sizes.

Safety

Great care must be taken when drilling. The guard on the drilling machine must always be in place before the machine is switched on, and during all drilling operations. There must be no loose clothing or long hair which could get caught up in the drill. The work must be properly secured against movement, and special care must be taken when the drill is breaking through the metal. Drilling sheet metal is particularly dangerous, and great care is needed.

Twist Drills

Twist drills are classified by the shape of the shank. They are identified by the size and material from which they are made.

Parallel Shank

Parallel shank drills are usually made up to 12 millimetres or ½ inch in diameter. They are used mainly with hand tools or small pillar drills, and fit in an adjustable chuck.

Parallel Shank (jobbers series)

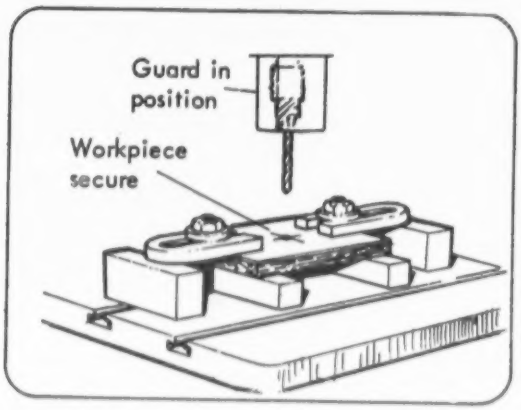
This type of drill is in most common use and can be used in drilling machines, hand-held drilling machines and machine tools.

Drill Sizes

Standard sizes range from 0.20 millimetres up to 16 millimetres; or from 1/64 inch diameter up to ½ inch diameter.

Care should be taken to avoid breaking a drill in the workpiece. It is difficult to remove, and may result in the work being scrapped.

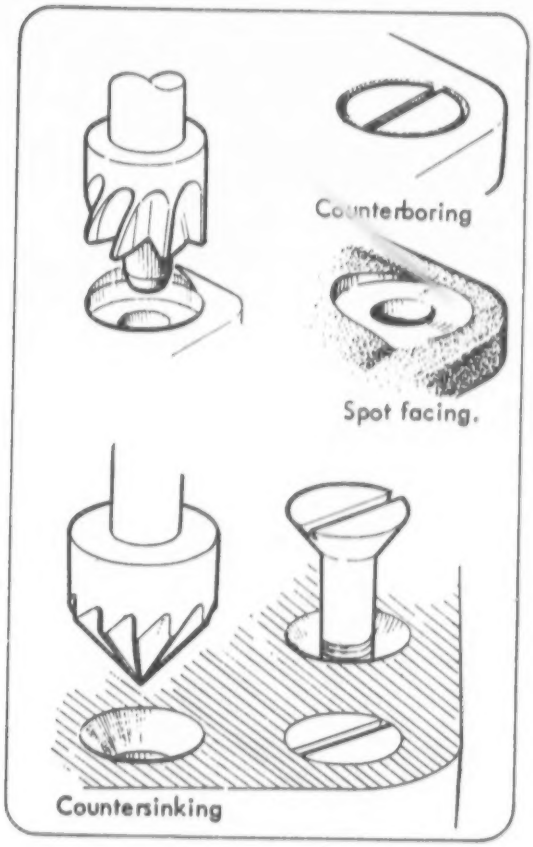
To prevent a drill from breaking it should be used at the correct speed and feed. The swarf should not be allowed to jam in it, and the lands must be in good condition. Proper use of a suitable coolant will also help to avoid breaking drills.



Safety

1. The work must be properly secured.
2. There must be proper support for the break-through.
3. Particular care must be taken in drilling sheet metal.
4. The guard on the drill must be in position before and during drilling.
5. Hair must be short or covered.
6. No loose clothing should be worn.

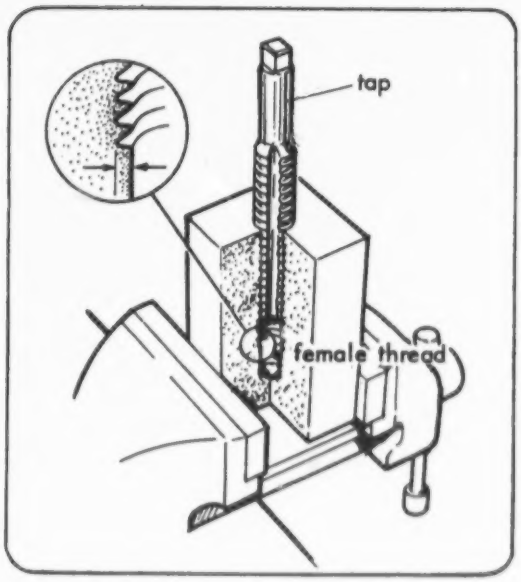
Cutting Fluids/Coolants
Where applicable a suitable coolant should be used.



Counterboring
Needed to form a flat, recessed seating for a cheese-headed bolt.

Spot Facing
Needed to form a flat seating for a securing nut or bolt.

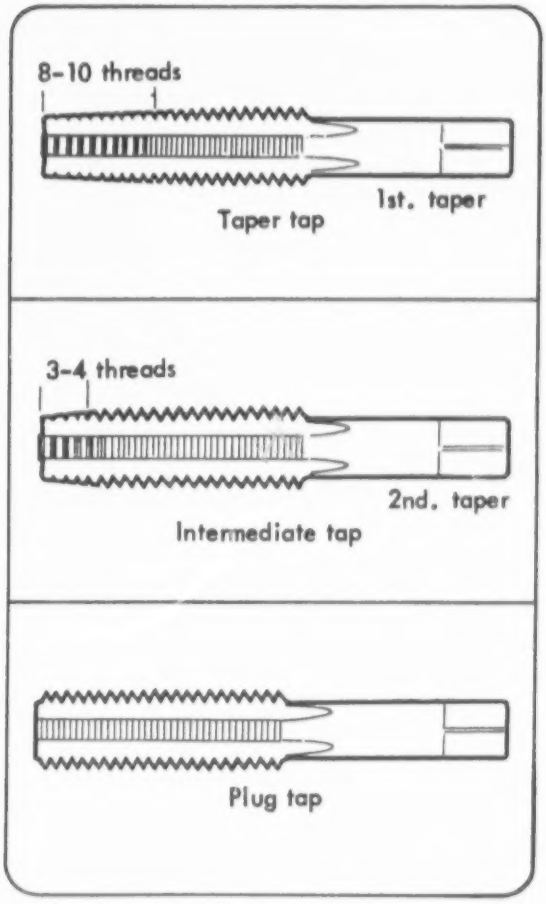
Countersinking
Needed to enable the head of the screw to fit flush with the surface of a component.



Taps
A tap cuts an internal (female) thread, either left or right hand.

Set of Taps
Taps are usually made in sets of three: a taper tap, an intermediate tap, and a plug tap.

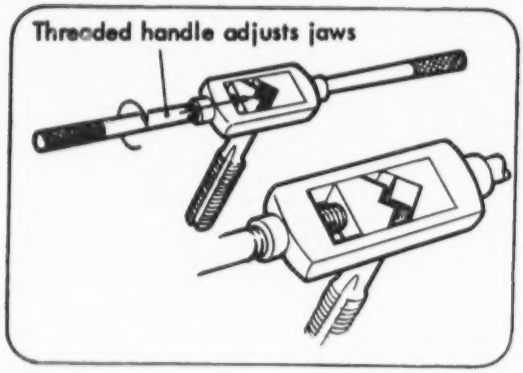
Safety
Beware of cutting edges when handling.



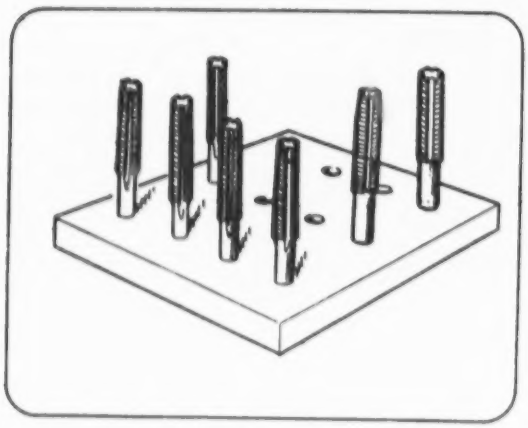
The Taper Tap
The taper tap is tapered off for 8 to 10 threads, and is used first, cutting to the full thread gradually.

The Intermediate Tap
The intermediate tap usually has three or four threads chamfered. The second tap can finish a through hole.

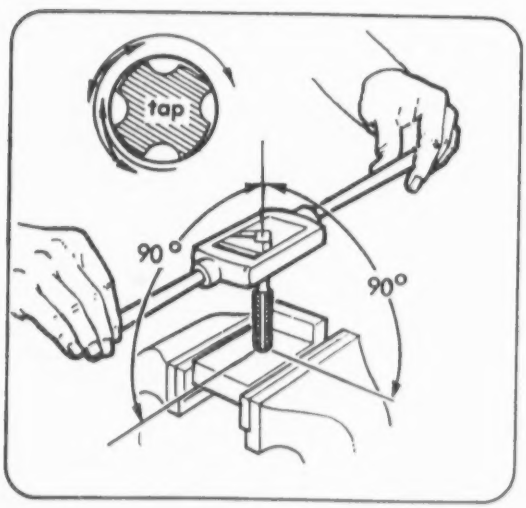
The Plug Tap
The plug tap has a full-sized untapered thread to the end, and is the main finishing tap. In the case of a blind hole, a plug tap must be used.



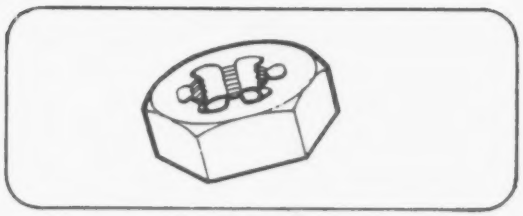
The Wrench
The appropriate size wrench should always be used for a given tap, to ensure that the jaws fit correctly.



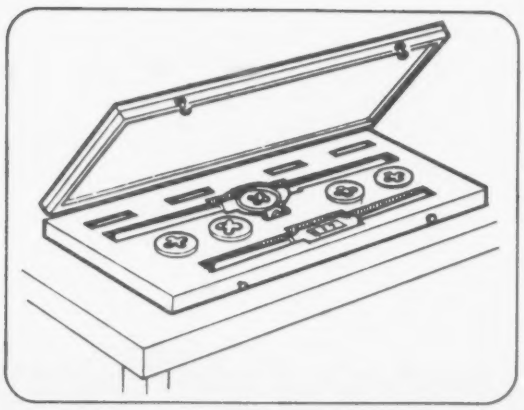
Care of Taps
Care must be taken not to damage the cutting edges. A chipped tap must never be used. When not in use, taps should be kept clean, and stored in a rack.



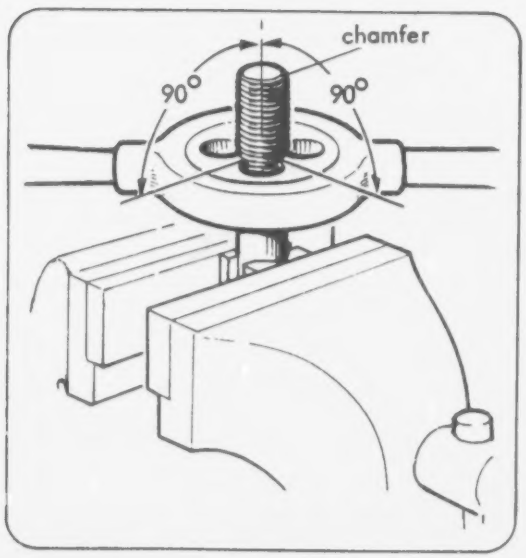
Using Taps
A hole must be drilled to the tapping size for the thread. The workpiece must be securely supported. When starting the cutting, the tap must be at 90° in all planes to the work. Excessive force must not be used, as this will result in breaking the tap. Cutting fluid should be used. The threads must be cleared as often as is necessary to prevent flute clogging.



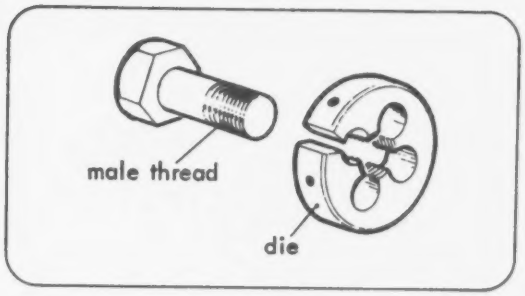
The Solid Die Nut
A solid die nut is used to repair a damaged thread, not to cut a new one.



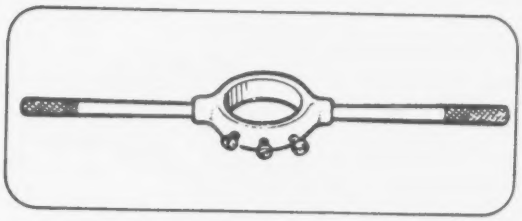
The Care of Dies
When not in use, dies should be kept clean and stored in a partitioned box to prevent damage to their cutting edges.



Using Dies
The work should be chamfered for ease of starting. The workpiece must be securely supported, and vertical in the vice. Great care must be taken to start the thread true to the axis of the bar. Lubricant should be used. The threads must be cleared as often as is necessary.

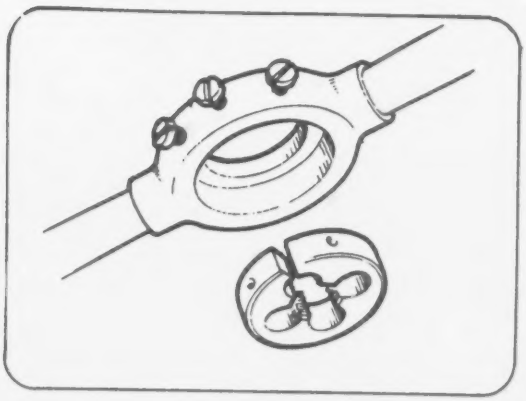


Dies
A die cuts an external (male) thread, which may be right or left hand. A die is made of high quality tool steel, suitably heat treated.

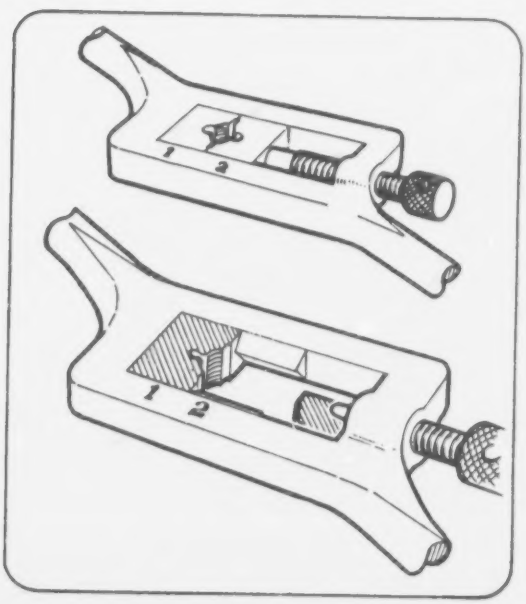


The Stock
A die is held in, and turned by, a stock.

Types of Dies
There are button dies, half dies, and solid die nuts.



The Button Die
The button (or split) die allows a limited amount of adjustment in the depth it will cut, by means of screws in the stock which spring it open or shut. It should be fully open for the first cut, and then gradually reduced to finished size. It must be checked against an existing thread or die nut of correct size.

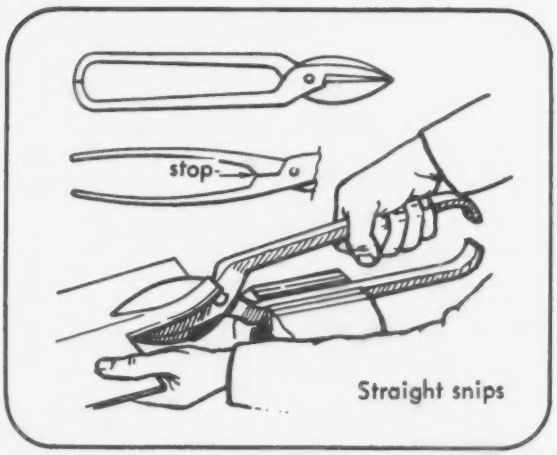


Half Dies
Half dies have the advantage of taking smaller cuts to reach correct size, so the amount of material taken off can be controlled. Half dies are in matched pairs, and should always be used together.

Hand Cutting Tools

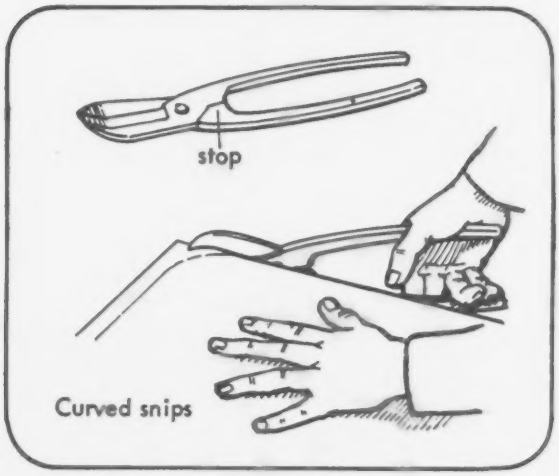
Snips and Shears

It is important that the correct tool for the job is used.



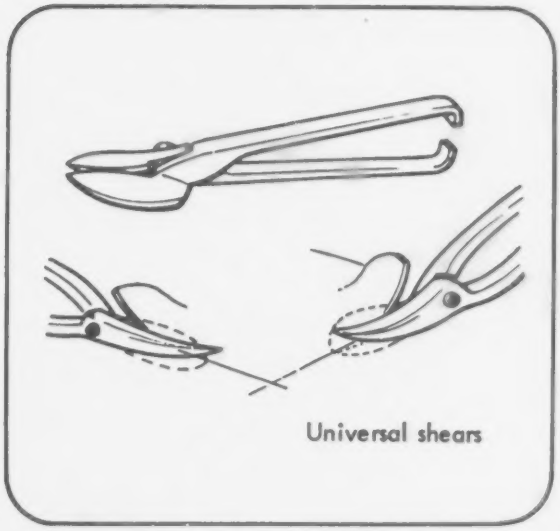
Straight Snips

Straight snips are used for general purpose cutting, making straight cuts and trimming away surplus metal where free access and manipulation of the handles can be obtained.



Curved Snips

Curved Snips are used for cutting circles or irregular curved shapes. Common sizes range in length from 20 cm to 35 cm in 5 cm steps.



Universal Shears

The handles of universal shears are offset, allowing cuts to be made in any direction. They are mainly used for cutting enclosed shapes in metal.

These shears are right or left handed, and this is determined by the position of the top blade in relation to the bottom blade. For some operations it is necessary to use both right and left handed shears.

Safety

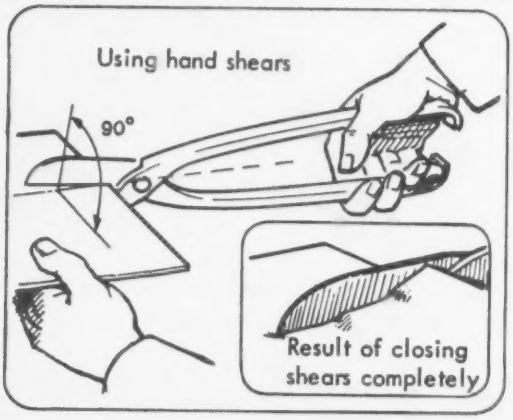
Working with Sheet Metal

Sheet metal stock and material that has been sheared has sharp edges that will easily cut bare flesh.

Gloves should always be worn when handling sheet metal.

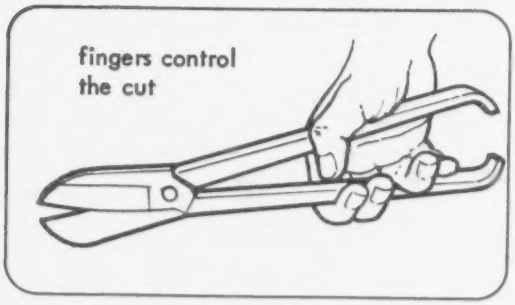
Stacks of metal sheets should not be placed near machines as vibration can cause the stack to creep and eventually collapse with the subsequent risk of injury.

Safety footwear should be worn to prevent serious injury to feet.



Using Hand Shears and Snips

The handles should be gripped as far as possible from the blades. The cutting blades should be held at right angles to the workpiece, and aligned with the cutting line. The shears or snips should never be completely closed in any cut, as this distorts the edge of the work, and gives a ragged line of cut. All materials which have been cut with shears should be handled with the utmost care.

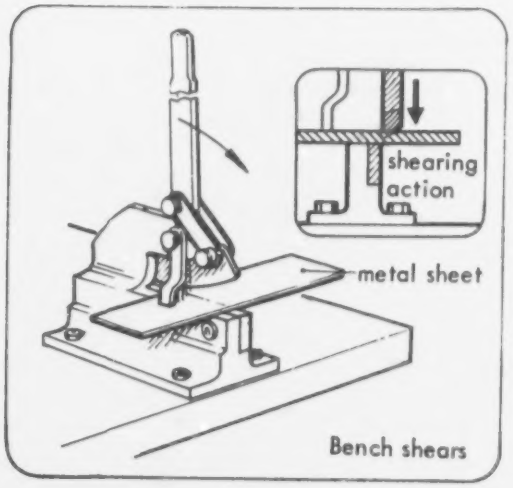


Safety

Where stops are not fitted, care should be taken not to pinch the palm of the hand between the turned-in ends of the handles when closing the cutting blades.

Heavy Duty Cutting Tools

Using snips and shears is practicable if the metal being cut is of light gauge. As the metal increases in thickness, more robust tools and greater leverage are needed.

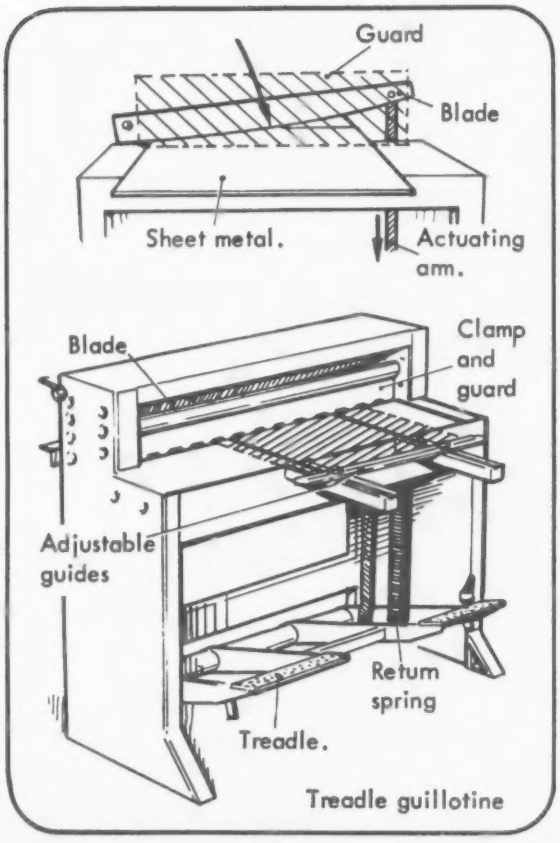


Bench Shears

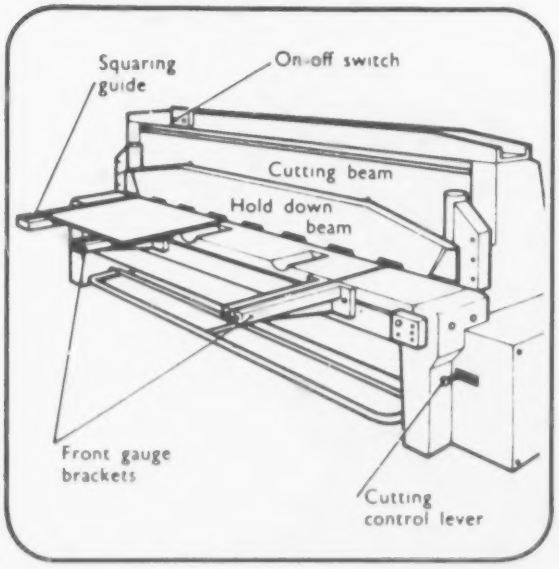
Bench shears provide a quick and safe way of cutting thicker metal. They must not be used beyond their specified capacity.

Safety

If the bench shears are aligned along the bench, when not in use, the handle should be left down, so that the jaws are closed. If the shears are aligned across the bench, when not in use, the handle should be left upright, out of the way. Some method of locking the handle in this position is essential.



Treadle guillotine



Setting and Operation of Guillotines

Treadle Guillotine

The bottom cutting blade is fixed in the machine bed and the top blade is operated by the treadle. The material to be cut is placed on the bed and held firmly in position by hand. The hold-down clamp comes into operation when the treadle is depressed and provides adequate cover to the blades.

Safety

All guillotines are dangerous. They must never be used unless the guard is in place. It is illegal to work from the back of a guillotine.

Power Operated Guillotine

On some power operated guillotines provision is made for a single or continuous cutting action.

If in doubt as to the position of the cutting control, check as follows:—

(a) Switch on guillotine

(b) Depress pedal

If the control is set for single cutting the cutting beam will descend once for each depression of the pedal and the pedal must be released between each cut.

If the controls are set for continuous cutting the beam will continue to rise and descend while the pedal is depressed.

Safety

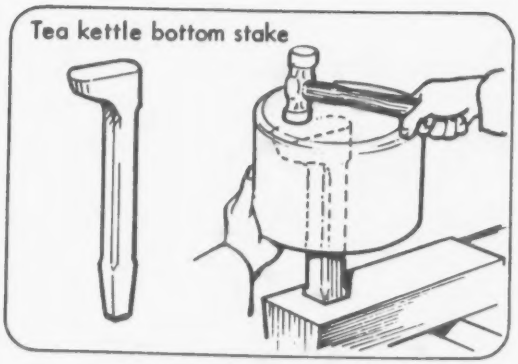
Before using any guillotine, its safe operation must be fully understood. Particular note should be taken of the position and operation of any emergency switches, or methods of immobilisation. Before switching on, ensure all guards are in place and back of guillotine is clear of personnel. Gauges, if not being used, should be clear of material being cut.

Hand Forming Tools

Once sheet metal has been marked out and cut to size, it then has to be formed into its final shape. Much of this work is still done with hand tools.

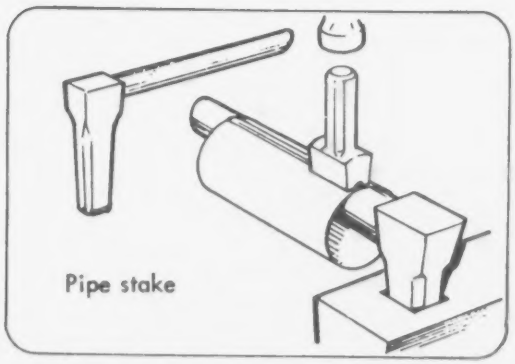
Bench Stakes

Bench stakes are used to support the work. They have many different shapes and sizes, depending on the article being made, and the process being carried out. Stakes are rigidly held by fitting into square tapered holes in the work bench, or by being held in a special casting.



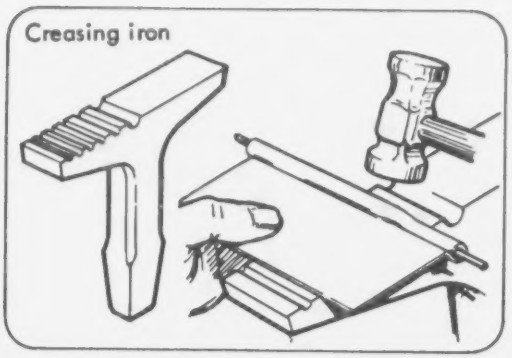
Tea Kettle Bottom Stake

This stake is used to fit bottoms to circular or square liquid containers. It is also used as an underneath support when hand wiring a cylinder.



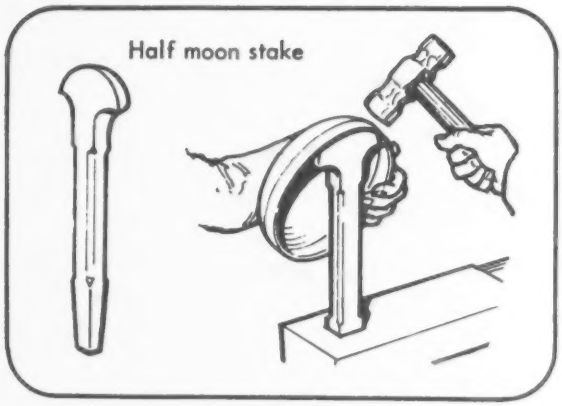
Pipe Stake

The pipe stake is used to shape cylinder sides. It is also used for hand grooving circular pipe joints.

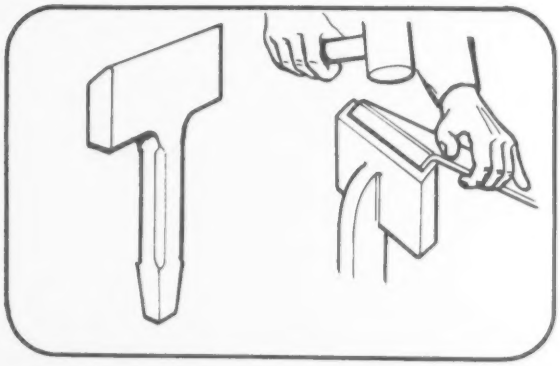


Creasing Iron

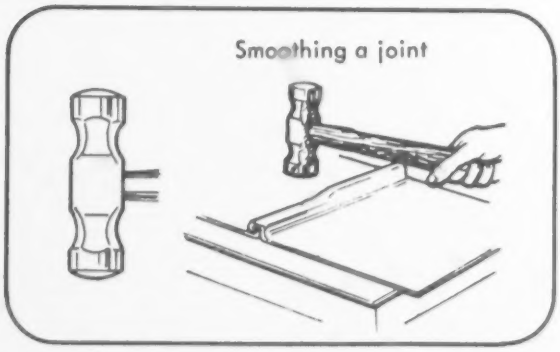
This is used for hand wiring flat sheets. The flat-surfaced end may be used for closing down edges, or squaring up worked joints.



Half Moon Stake
This stake is used for flanging operations on cylindrical shapes.

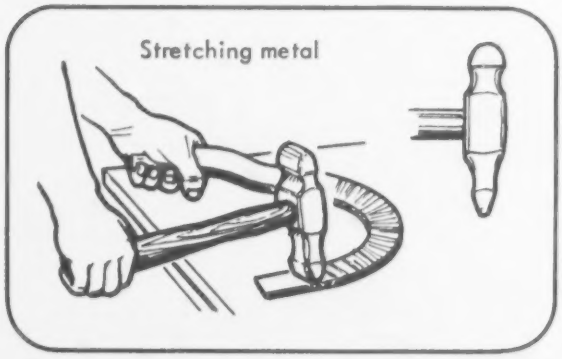


Hatchet Stake
The hatchet stake is used for flanging straight sided or inside curved work.

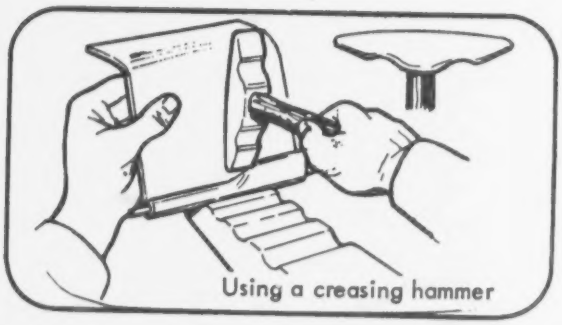


Hammers
Hammers or mallets are used in conjunction with bench stakes. The final shape achieved is the result of using a combination of hammers in their correct sequence.

Smoothing Hammer
The smoothing hammer is used for levelling and working over joints.

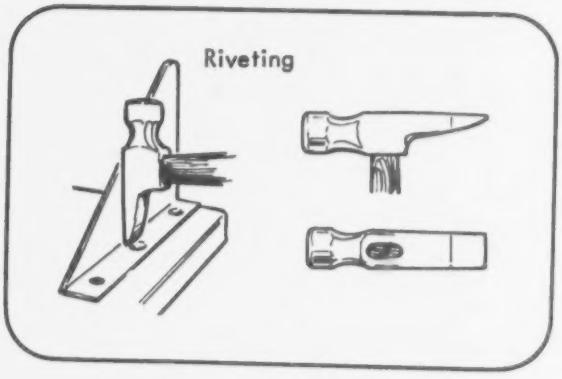


Stretching Hammer
The stretching hammer is used for stretching metal.



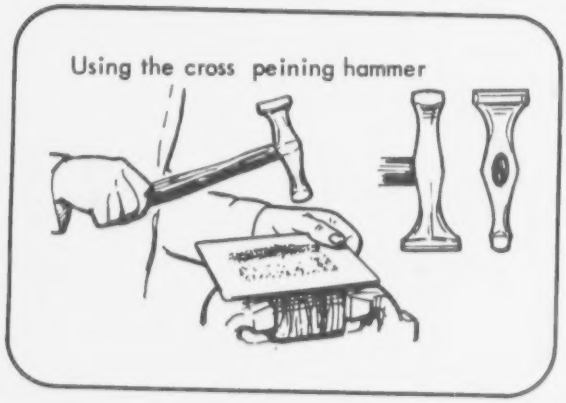
Using a creasing hammer

Creasing Hammer
The creasing hammer is used to close down joint edges.



Riveting

Riveting Hammer
The riveting hammer is used for forming rivet heads.



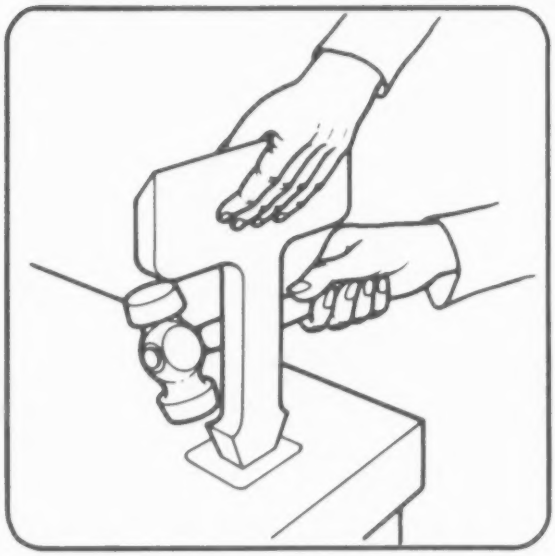
Using the cross peining hammer

Cross Peining Hammer
The cross peining hammer is used for thinning down material.

Before hammering, the metal should be annealed if necessary, and the surface should always be clean.

Safety

Hammer heads must be firmly fixed. Striking faces should be smooth, unchipped and well polished.



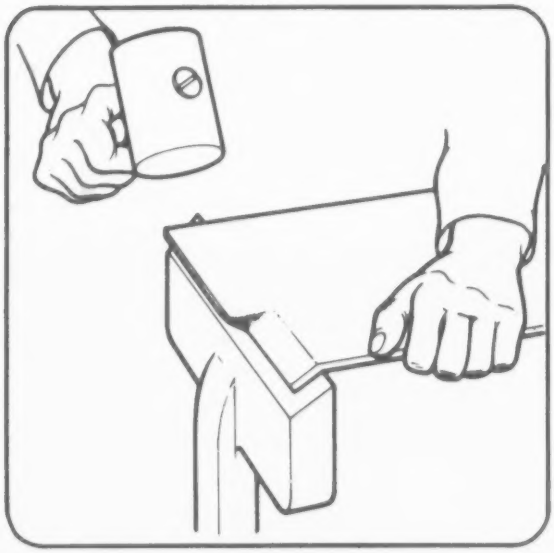
Use of Hatchet Stake

Used for flanging straight sided or inside curved work. Also used for external flanging or cylindrical work. The working edge of the stake is bevelled to enable flanges of more than 90^{O} to be formed. The stake edge should not be too sharp to avoid any danger of cutting the metal being formed.

Stake is normally mounted in cast iron socket or bench socket as shown.

Position stake at right angles to craftsman, face towards left hand.

Tap firmly to ensure firm seating.

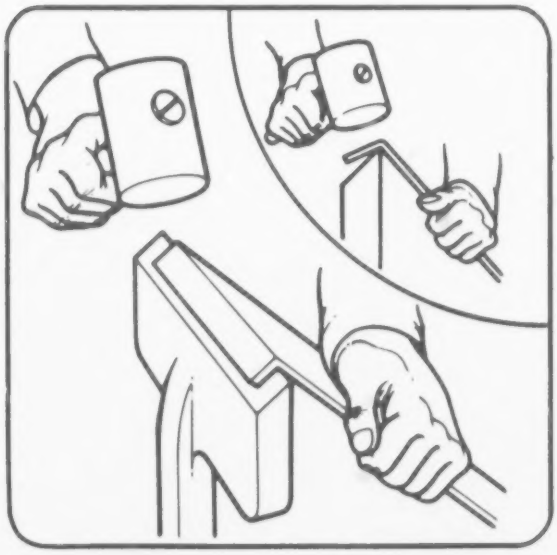


Flanging a straight edge

When flanging a straight edge, support work as shown, left hand gripping far edge and forearm applying light downward pressure. This grip will maintain work in contact with edge of stake.

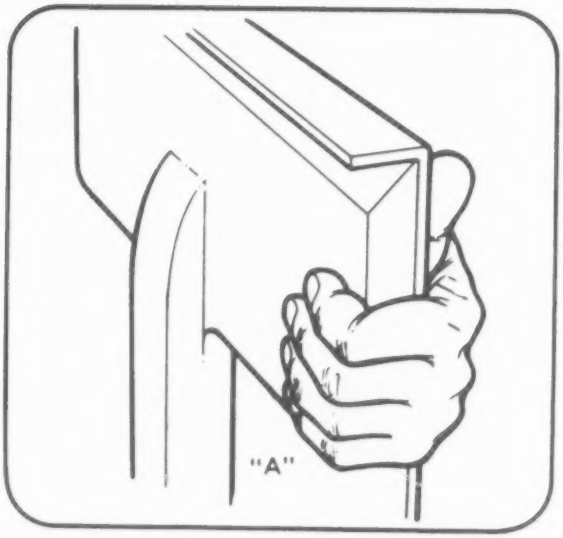
(a) Position previously marked folding line on edge of stake.
Keep work horizontal.

(b) With a beech or boxwood mallet, strike edge of work at both ends, using a slightly angular motion.
Observe "break" or fold mark formed. This should follow marked line.

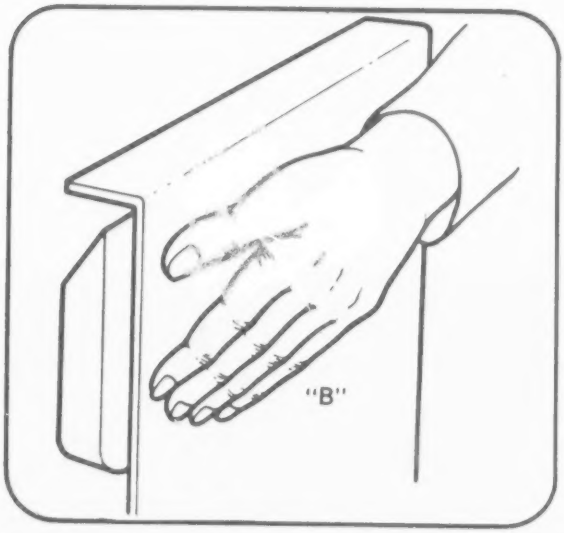


(c) Lower end of work slightly. Using same angle of striking, increase angle of flange.

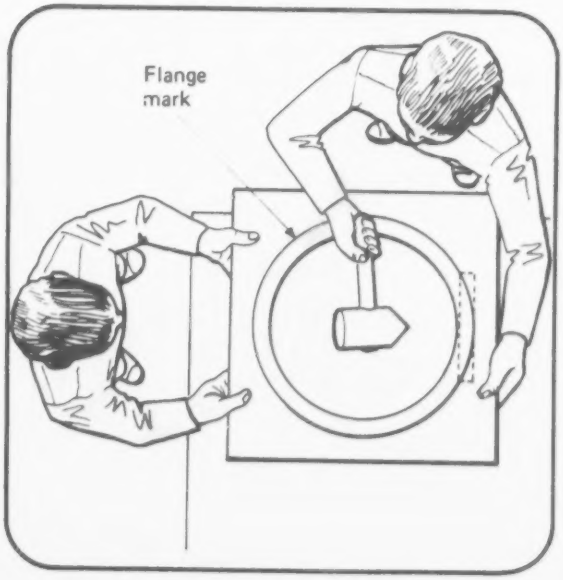
(d) Repeat operation (c) until flange is at required angle.



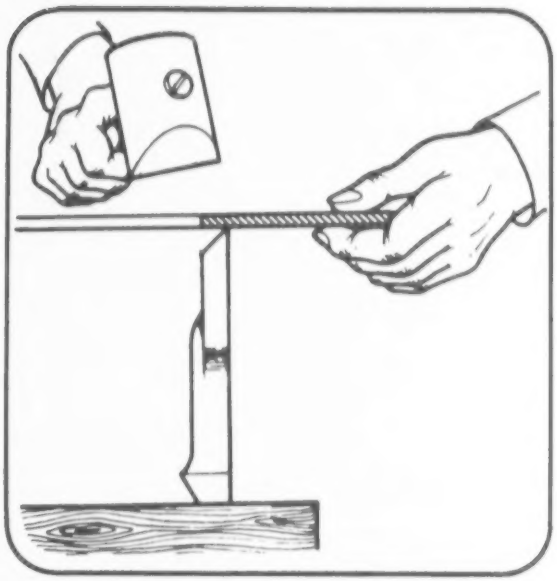
Note: When forming flanges of more than 90° support work flat against face of stake as shown at "A", fingers gripping stake, thumb holding work in position.



Although the stake is normally used for small work, occasions may arise where the work is longer than the stake. Work will now be supported as shown at "B", hand spread to hold work in contact with face.



Forming a flange on an inside curve
A comfortable working position for small easily handled work is shown. Stake is positioned at right angles with face of stake on trainee's left. Support work with left hand maintaining sheet level.

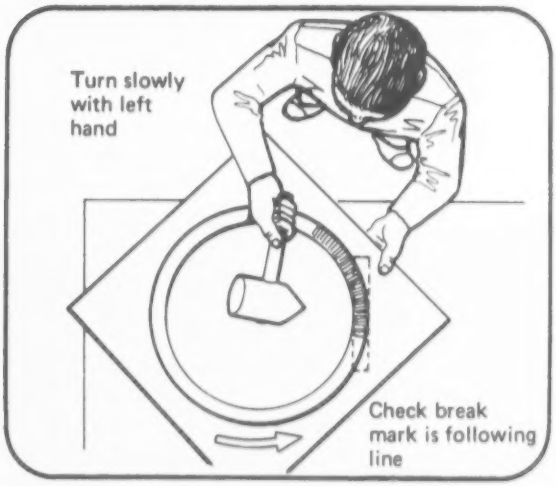


(a) Position flange mark over edge of hatchet stake.

Note: As edge cannot be seen, position will be approximate.

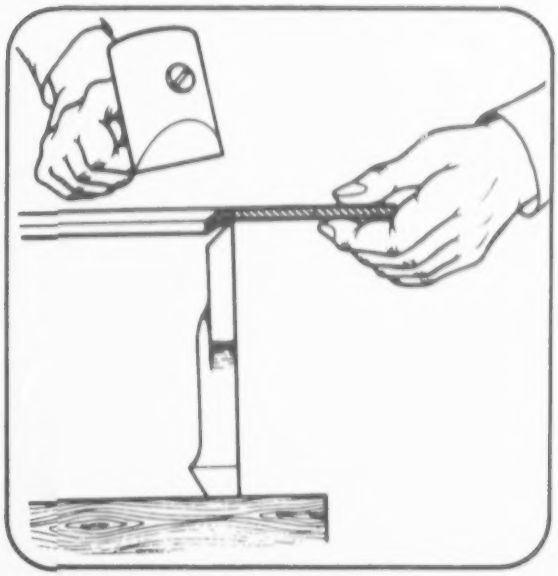
(b) Strike flange lightly with raising mallet. Observe position of "break" line.

If necessary, adjust work and strike again to bring "break" mark on to flange mark.



(c) Progress round flange mark, striking moving work in turn.
Observe break mark follows marked line.

Change position of left hand as required, to maintain a comfortable working position.

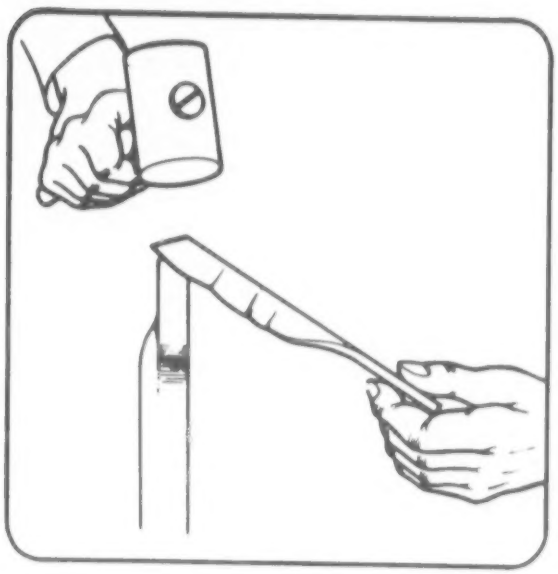


(d) When break mark is complete, lower left hand and repeat striking and moving operation all round flange.

(e) Repeat operation, lowering hand slightly each time.

Notes: (i) For final flanging operation it will be advantageous to use mallet from underside of sheet.

(ii) Where thicker materials or wide flanges are being worked, slight stretching of the metal using a stretching hammer may be necessary, to reduce the danger of splits forming.

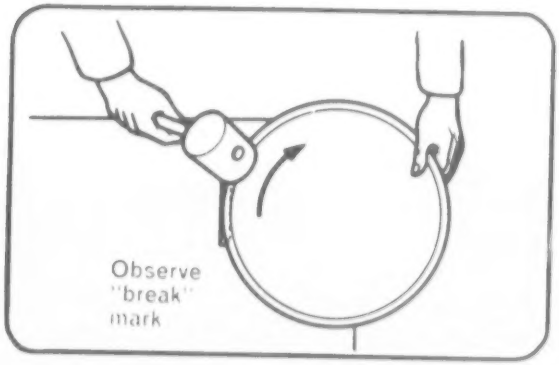


Use of Half Moon Stake

Edging a disc

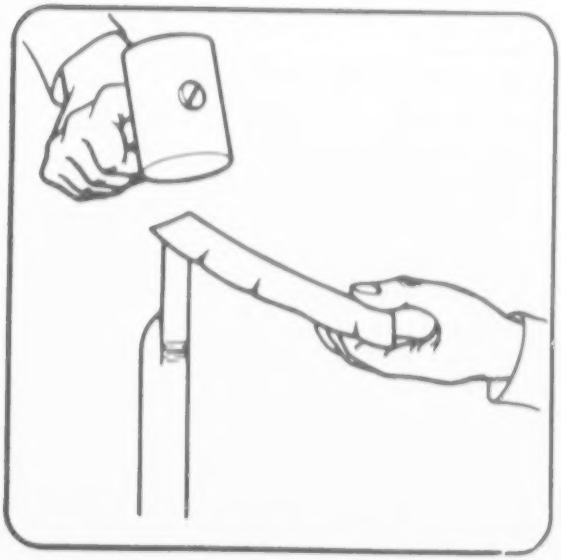
(a) Position previously marked guide line on half moon stake.

(b) Holding disc at slight angle, strike edge with mallet to form "break" mark.



(c) Turning disc slowly, strike edge to continue a break mark, changing position of left hand as required.
Keep mark on guide line.

(d) When "break" mark is complete, lower angle of disc and repeat striking and turning.



Note: As flanging progresses, wrinkles will be formed on edge and disc will be seen to buckle.

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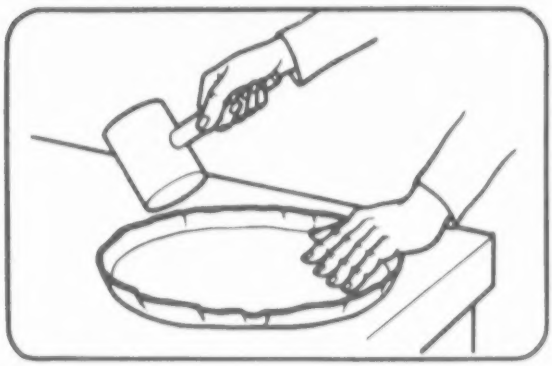
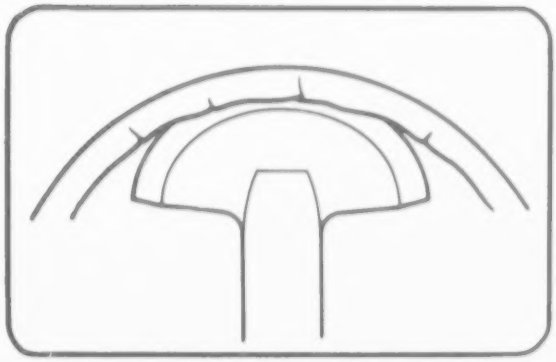


(e) Remove disc from half moon stake.
Place on a flat surface.

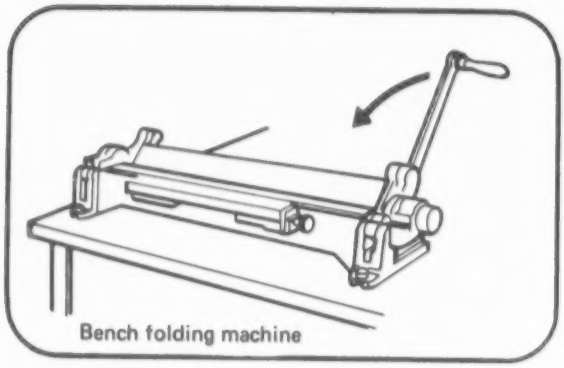
(f) Tap edge lightly with mallet to straighten disc.

(g) Return to half moon stake.
Position disc to allow flange to rest on bevelled edge.
Tap out wrinkles.

(h) Lower angle of disc and strike edge a little further over.



Repeat operations, straightening and removing wrinkles as necessary until edge is square to disc.

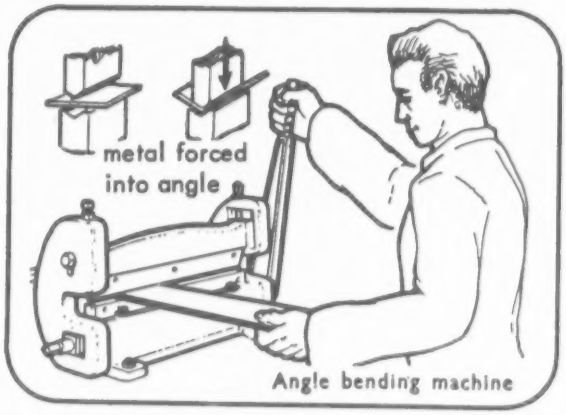


Bending and Folding Machines

Machines are used to carry out many of the basic metal forming processes.

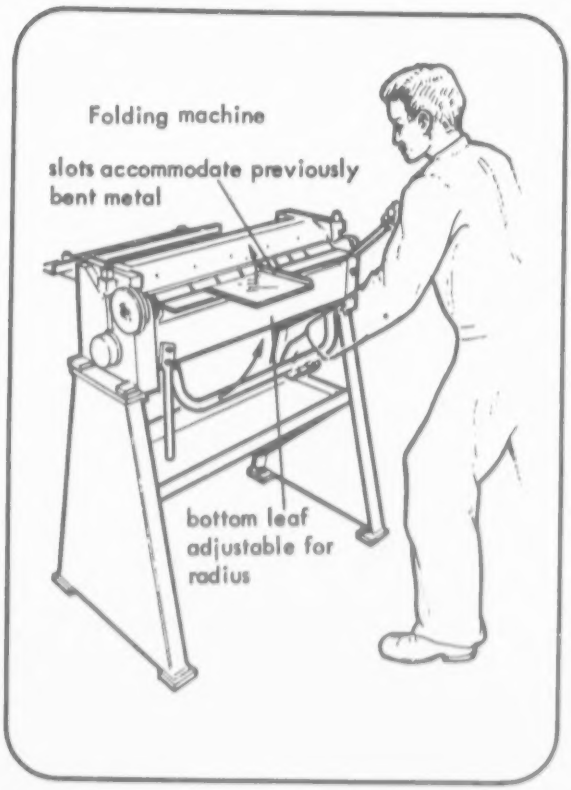
Bench Bending and Folding Machine

This is used for edging or flanging sheet metal of light gauge.



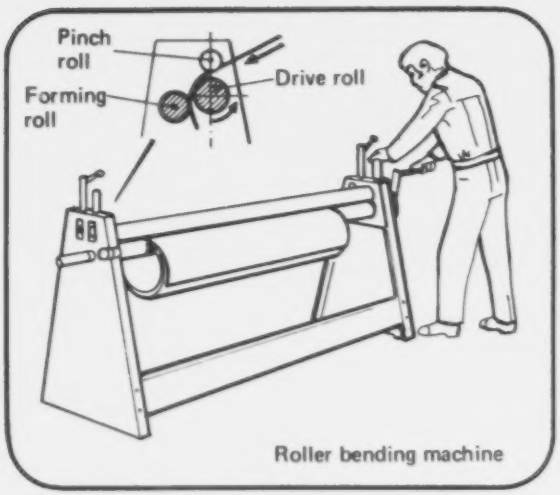
Angle Bending Machine

This machine is used for forming simple right angle bends in light gauge metal. The bend may be of small or large radius depending on the blades in use.



Folding Machine (Box and Pan Folder)

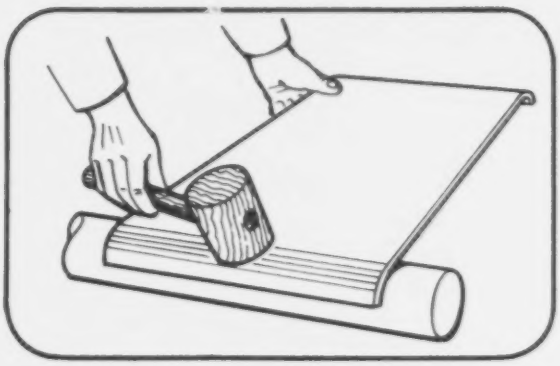
A bending machine can be used with heavier gauge metal. The top blade is made up in sections so that complete box and pan shapes can be built up from the flat sheet. The radius can be chan[illegible]d by adjusting the bottom leaf.



Roller bending machine

Setting and Operation of the Roller Type Bending Machine

These machines are usually of the "pinch" type with three rollers. The two front rollers are in vertical alignment, the top one being adjustable to grip the material. The back roller is adjustable to form curves of different radii. The bottom front roller has a swivel bearing which allows the completed cylinder to be withdrawn from the machine.



Setting edges on a bar or mandrel

Sheet edges must be set before rolling to prevent formation of flats at the joint. Edges must be set sufficiently far back to allow forming roll to continue the curve without formation of a flat area.

(a) Place sheet on a suitable bar or stake with the edge slightly overlapping.

(b) Strike edge of sheet with mallet.

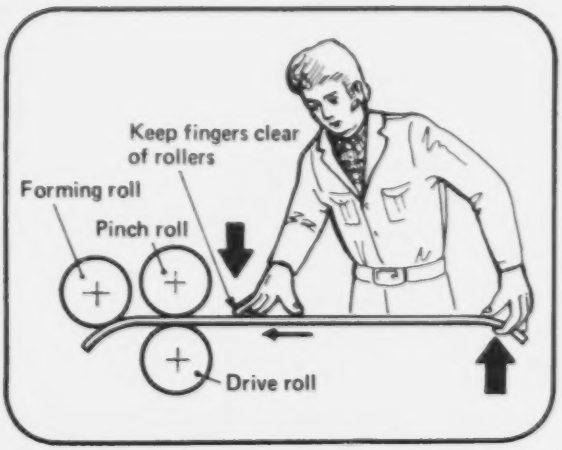
Safety

Ensure that mallet is free from splits and marks and head is secure on shaft.

(c) Form edge by striking slightly off the bar.

(d) Repeat operations (a) to (c) for other edge.

Note: Accuracy of set is not essential as cylinder will be finally trued after joint is formed.

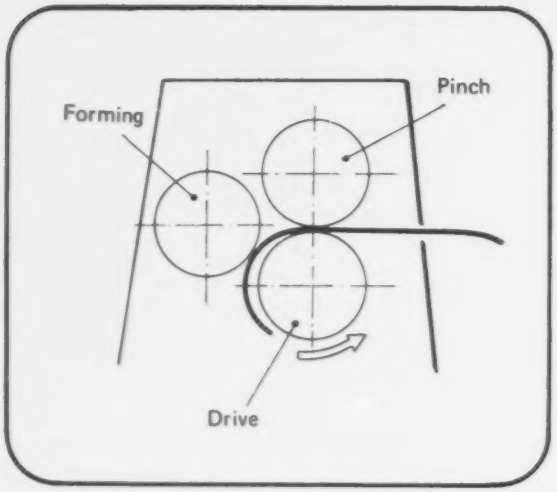


Forming a cylinder

(a) Lower forming roll until level with pinch roll. Count number of turns on each hand-wheel to ensure roll is parallel.

(b) Raise pinch roll by means of hand-wheel.

(c) Insert sheet between pinch and drive rolls until pre-set edge is below centre of forming roll.



(d) Lower pinch roll by adjusting hand-wheel until sheet is lightly held.

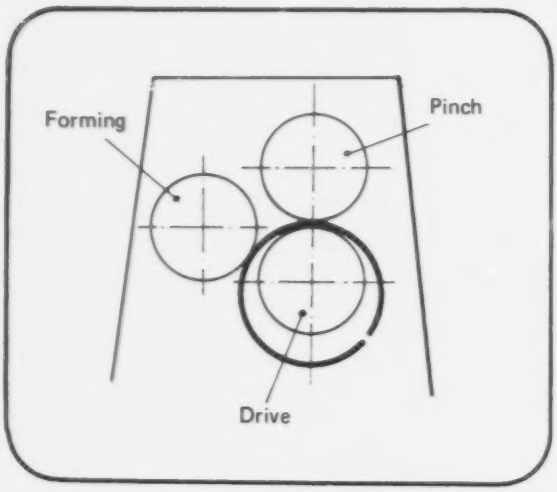
(e) Lower forming roll to engage leading edge of sheet. Turn hand-wheels equally to ensure roll is level.

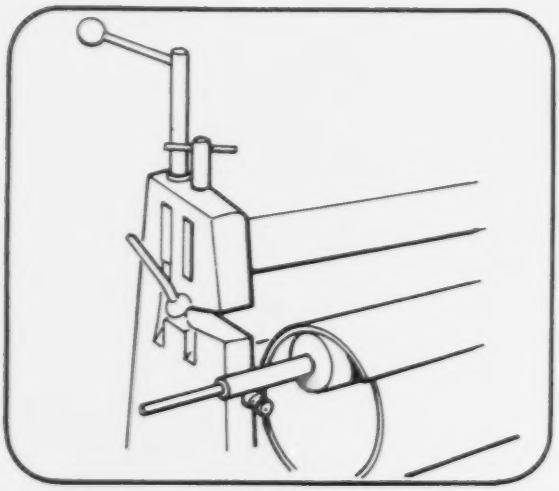
(f) Rotate drive roll handle to form curvature until trailing edge of sheet approaches the pinch roll.

(g) Rotate drive roll handle in reverse direction until sheet leading edge reaches the pinch roll.

(h) Lower forming roll, adjusting both ends equally.

(i) Repeat (f) (g) and (h) until complete cylinder is formed with edges in close contact.





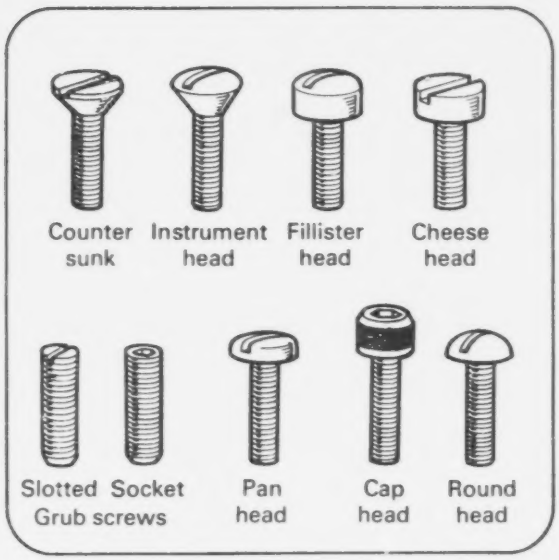
Removing a Cylinder

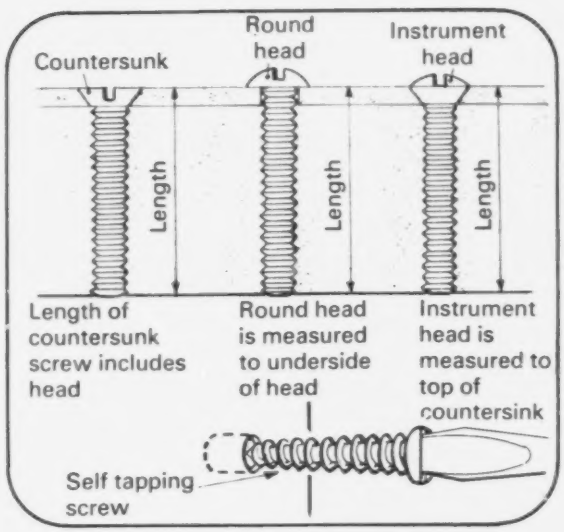
(a) Raise forming roll by means of hand-wheels.

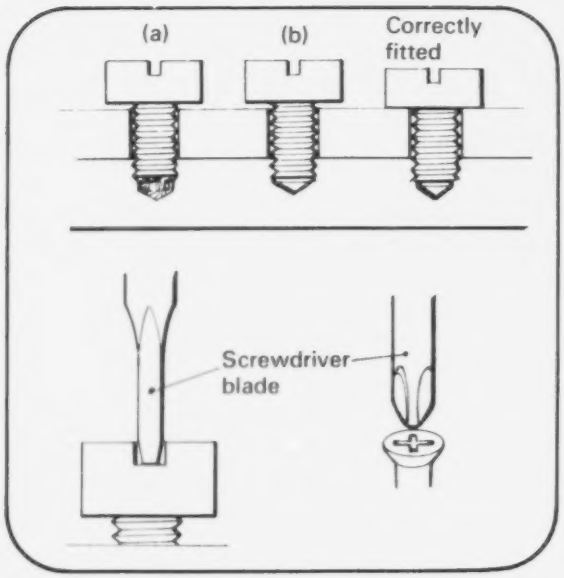
(b) Raise pinch roll.

(c) Release clamp on drive roll, swing out, and remove cylinder.

(d) Re-set drive roll and re-clamp.







Screws

Screws are used for securing components and assemblies and are identified by:

(a) Head type
Flush fitting screws are used when there is little clearance between assemblies or where protruding heads are not desirable.

The semi-flush type is used mainly for panel assembly or where a pleasing appearance is required.

The other full head types are used for general assembly work. As these heads are non-registering, some adjustment can be made to the relative positions of the workpieces by using the full clearance of the fixing hole.

(b) Screw length
Parts of the screw which protrude above the surface being fixed are not included when defining the length of the screw.

(c) Thread type
Various types of thread are available such as:
(i) Metric

(ii) BA (British Association)

(iii) UNF (Unified National Fine)

(iv) UNC (Unified National Coarse)

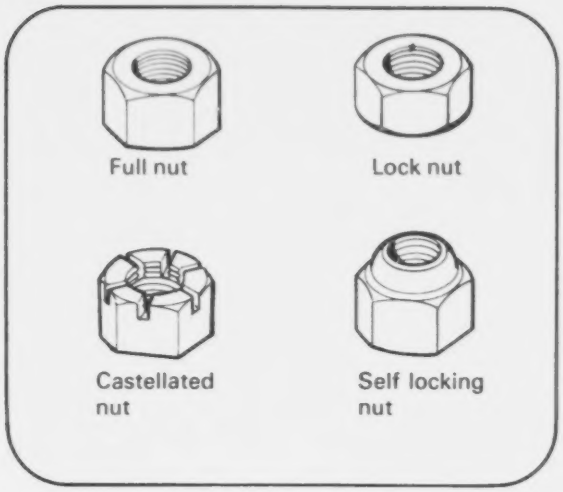
(v) Self tapping.

Screws will normally be screwed into tapped holes or used with nuts.

If the hole is blind, ensure (a) that there is no swarf in the bottom of the hole, or (b) the screw is not too long. The screw should be 1·5 mm shorter than the depth of thread plus the thickness of the part being secured.

Ensure that the blade of the screwdriver is a good fit in slotted head screws or damage to the slot will result.

Ensure that the correct type of screwdriver is used when fitting hexagon socket/cruciform slotted screws.



Nuts

Standard hexagon nuts are manufactured in two thicknesses:

(a) Full nut—used singly with or without a locking washer.

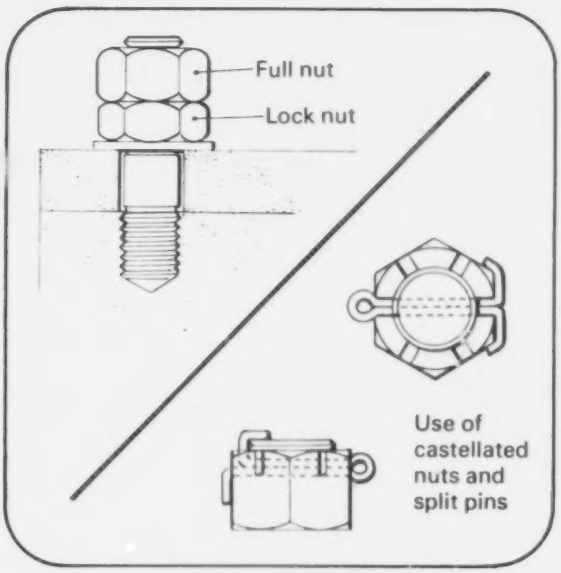
(b) Lock nut—used to lock another nut into a fixed position on a thread.

Special purpose nuts include:

(a) Castellated nuts for use with split pins.

(b) Self locking nuts with nylon inserts.

(c) Spring steel self locking fasteners.

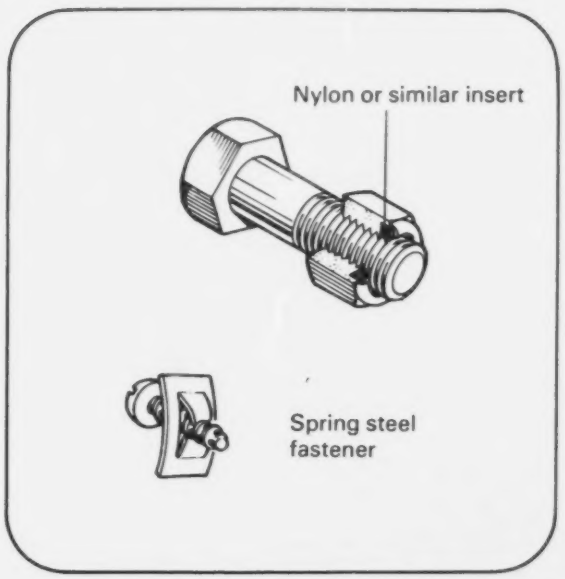


Use of lock nuts
A lock nut is placed *under* the main nut and tightened.
The main nut is run down on top of the lock nut and is tightened with one spanner while a second spanner prevents the lock nut from turning.

Note: The practice of placing the lock nut on top of the full nut weakens the assembly as the smaller number of threads in the lock nut take the strain.

Use of castellated nuts
(a) Assemble bolt with castellated or slotted nut.
(b) Drill clearance hole through bolt shank in line with slots.
(c) Push split pin through hole until head meets nut.
(d) Trim split pin 'ends' to length.
(e) Bend ends tightly around nut.

Note: Do not use split pins more than once.



When used in conjunction with proprietary lock nuts, the screw should protrude by at least one thread.

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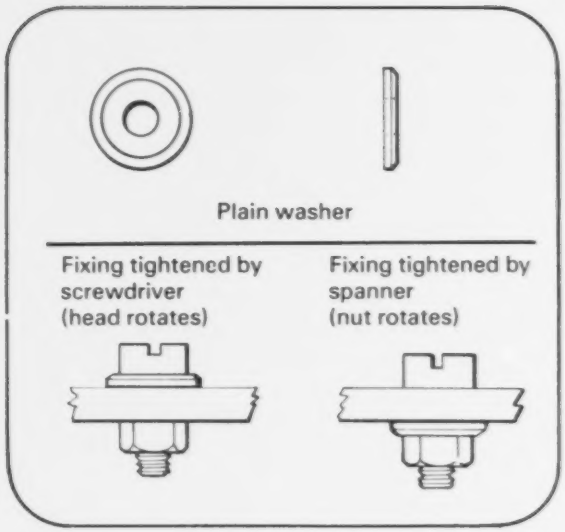
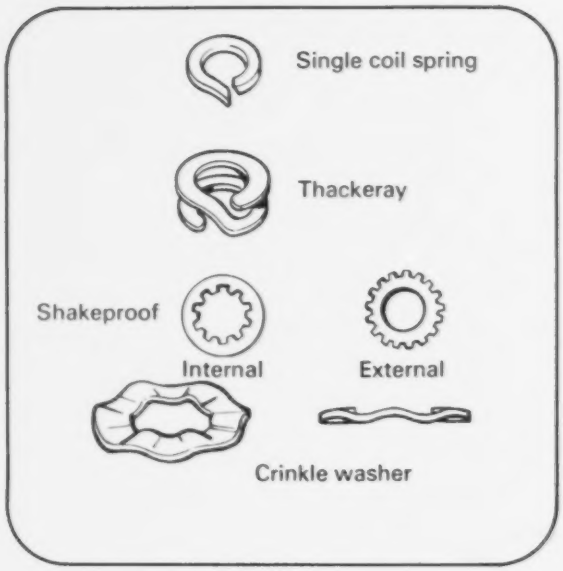


Washers

Plain washers are inserted under screw heads or nuts to provide a suitable bearing surface while tightening and to protect the component from damage due to rotation of the nut or screw head.



Lock washers

Locking washers are used to prevent loosening due to vibration, movement or temperature variation. Common types include:

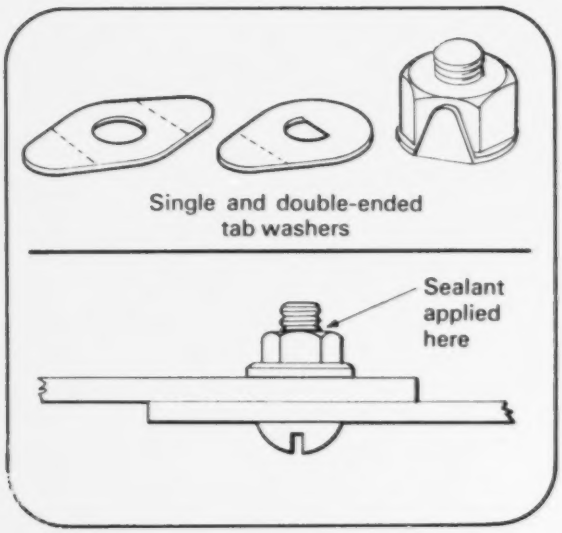
(a) *Single coil* spring washers normally made of square section spring steel, cut, twisted and chisel-edged.

(b) *Thackeray double coil* spring washers made of flat section steel or phosphor bronze.

(c) *Shakeproof* washers punched from spring steel. The outer or inner edge is slit radially in a number of places and the segments in between the slits are twisted so that several sharp edges bear against nut and work.

(d) *Crinkle washers* made from beryllium copper and are used where a lighter spring pressure is required.

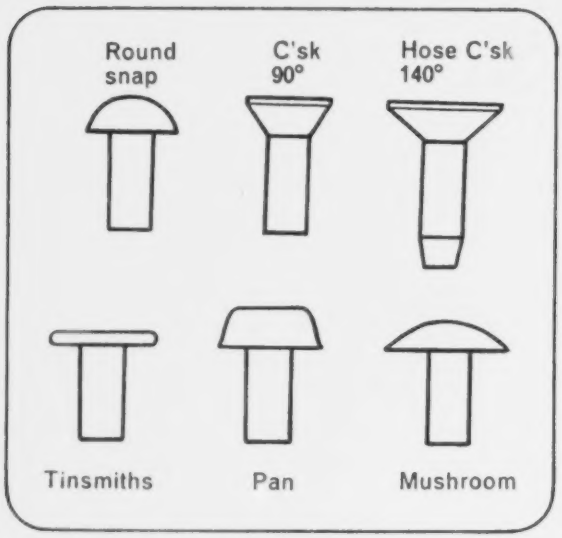
(e) *Tab washers,* used in special applications where a more positive locking action is required. The tab is bent up against the nut face, thus preventing it from turning.



Liquid sealants

These may be used to provide a permanent lock to a fixing point.

The sealant should be applied to the point where the thread emerges from the nut, using a small brush or the nozzle of the sealant container.

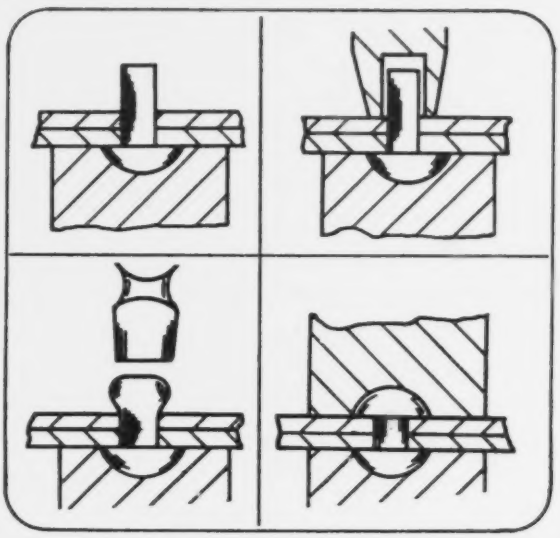


Riveting

Solid rivets may be closed hot or cold depending on size and material. A wide range of rivets is available, having different diameters, lengths, heads and made from mild steel, brass, copper, aluminium-alloy, etc.

If possible, use rivets made from the same material as the parts to be joined.

Do not use brass rivets for aluminium sheets or aluminium rivets for brass sheets if there is any possibility of dampness or moisture affecting the assembly—severe corrosion will then take place.



1. Choose suitable diameter rivets—generally 1½ times the thickness to be joined.

2. Choose a suitable length rivet—material thickness plus 1½ times diameter.

3. Remove all burrs from edges of holes.

4. Support rivet on suitable underlay or "dolly".

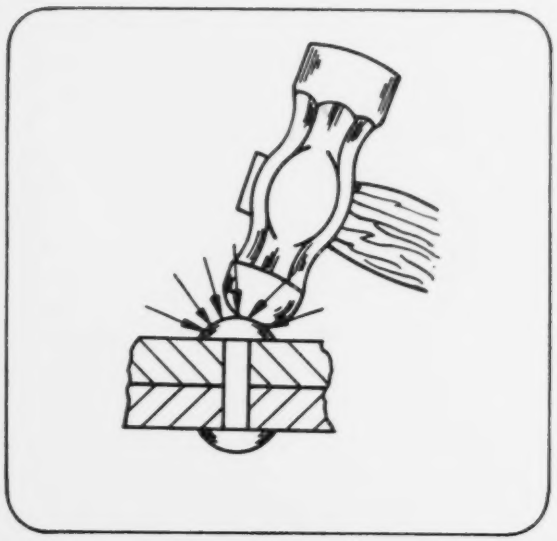
5. Use a "closing set" and draw the sheets of material together with a few blows from the hammer.

6. Use a hammer (flat) to partially form the head with a few blows.

7. Use a "rivet set", "rivet snap" or "dolly" to give a neatly formed head.

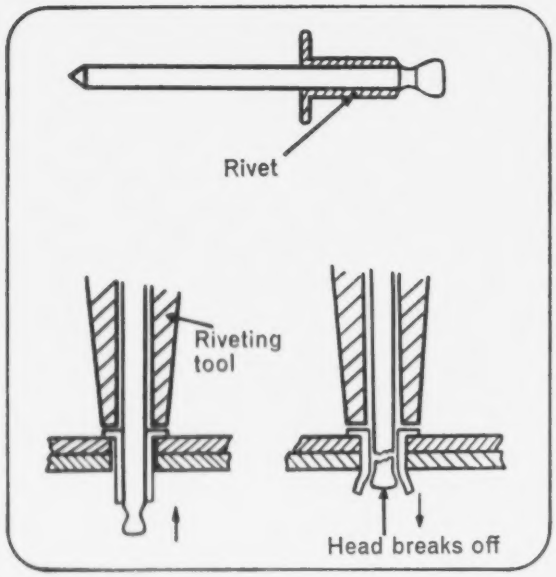
For air-tight or water-tight joints it is usual to use red-hot rivets.

On cooling these contract and produce a very tight joint.



If a "rivet set" or dolly is not available, use a ball-peen hammer and, striking glancing blows, work round and round the rivet forming the head.

Do not strike vertically downwards too much or the rivet will be spread out, forming a weak pankcake head.



Hollow rivets are used for joining thin material.

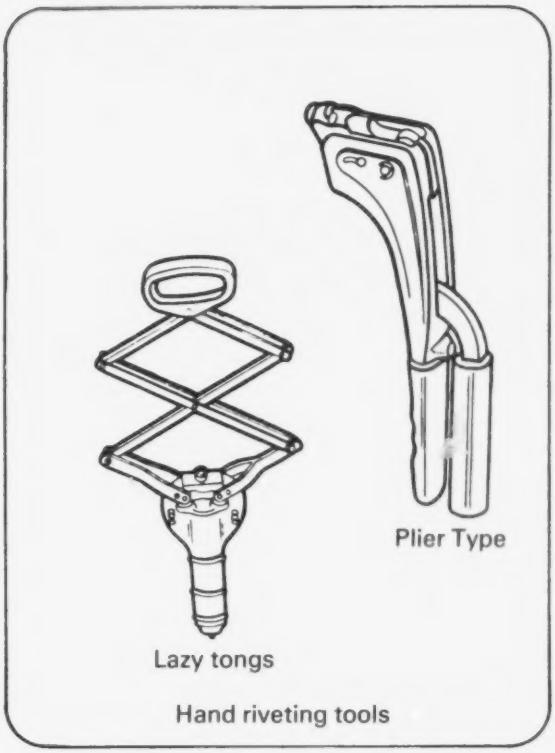
They are made from various materials and the same comments as to corrosion of aluminium with brass or copper in damp situations apply, as for solid rivets.

Typical dimensions for hollow rivets are:

Diameter 2.4 3.2 4.0 4.8 5.6 6.4 mm

Length 4–16 mm

These will join material thicknesses from 0.4–12.5 mm



Hand riveting tools

Procedure

1. Select suitable diameter rivet.

2. Select suitable length rivet, usually material thickness, plus 3–4 mm.

3. Drill clearance holes through parts to be joined.

If more than one rivet is to be used, clamp parts together and drill all holes through both parts together to ensure alignment.

Alternatively set rivet in first pair of holes, drill second pair of holes and set rivet, drill third pair of holes and set rivet, etc.

4. Insert mandrel into nozzle of tool and push in until flange of rivet rests on nozzle of tool.

5. 'Close' the rivet by operating the tool.

Safety

Used mandrels should be removed from the workshop floor as they provide a dangerous footing and create a safety hazard.

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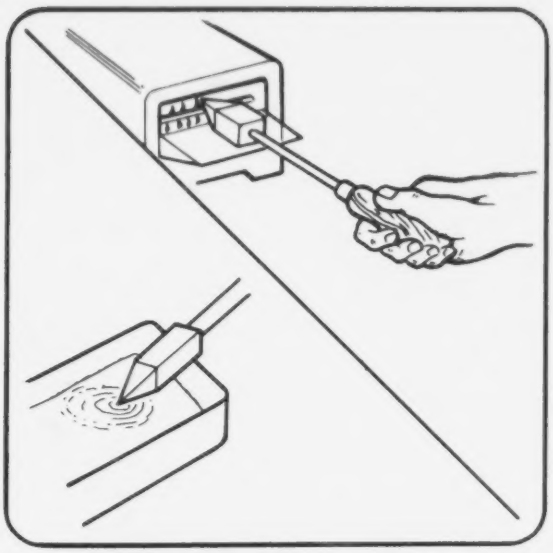
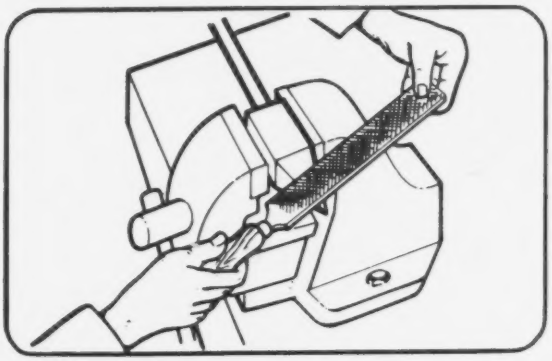
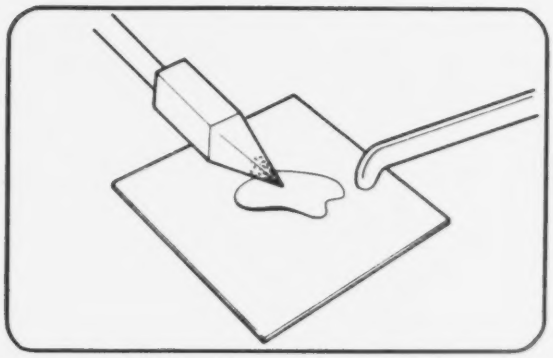






Soft Soldering

Lap soldered joints

Preparation:

(a) Clean lap area thoroughly.

Note: Where a lap joint is required on mild steel, both sides of top lap should be cleaned and tinned, to assist heat transfer when soldering.

(b) Prepare soldering bit.

(i) Heat bit in gas stove.

(ii) Observe gas flame colour. When flame turns green, remove bit and apply point to flux.

(iii) Observe faces of point. Tinning should appear a bright silvery colour evenly deposited. Should tinning appear dull, bit is too cold. Return to stove for further heating then re-check.

A rough lumpy appearance, or black pitting will indicate that re-tinning should be carried out.

(c) Re-tinning.

(i) Heat bit until copper starts to blacken.

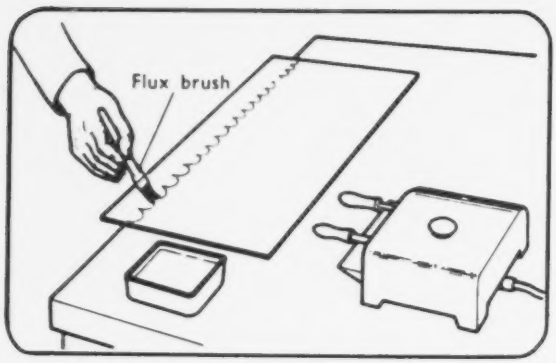
(ii) Remove from stove and support in vice.

(iii) File faces of point in turn. About 1/3rd of tapered part is generally sufficient.

(iv) Remove from vice and apply faces to flux.

(v) Apply solder to faces. Solder will flow over cleaned parts.

An alternative method is to drop solder on a piece of tinplate. Rub faces of bit on this until well tinned.



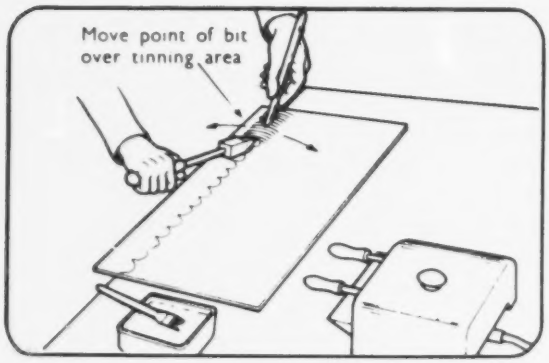
Tinning the lap areas

(a) Place sheet on soldering bench.

(b) Apply flux sparingly to lap area.

(c) Check temperature of soldering iron.

(d) Apply correctly heated bit to flux.
This will remove oxide film from tinned faces.



(e) Apply bit to work and apply solder to point of bit.

Spread solder evenly on surface. Keep tinned face of bit flat to obtain maximum heat transfer.

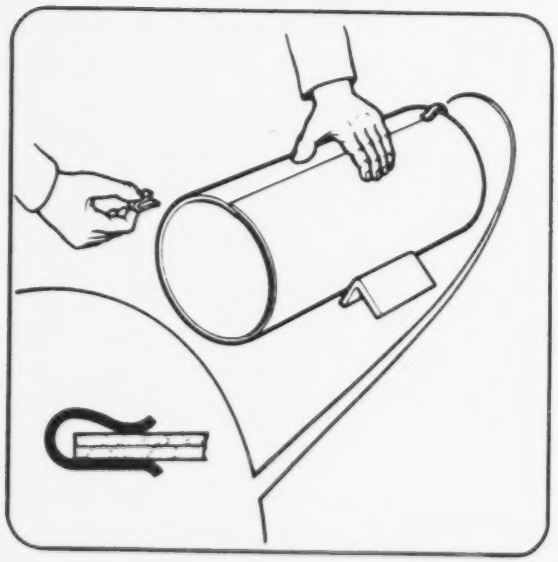
Apply more solder as required.

(f) Turn sheet over.

Tin other lap area in same manner.

(g) Using wet rag, clean off excess flux.

Form to shape.



Tacking

(a) Mark total overlap. (Original marks will have been tinned over.)

(b) Set edge of sheet to overlap mark.
Clamp.

Note: If toolmakers, or G clamps are used, clean thoroughly after use to remove any trace of flux.

(c) Support work, to prevent rolling.

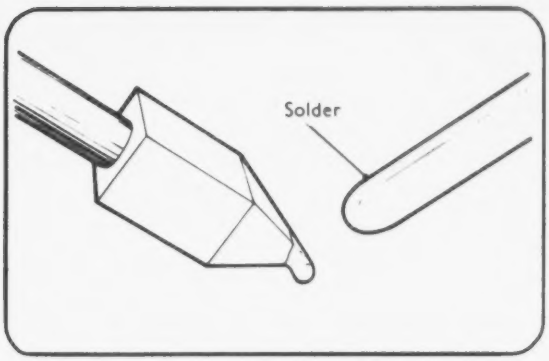
Check Dimensions. Adjust if necessary.

(d) Apply flux sparingly to joint.

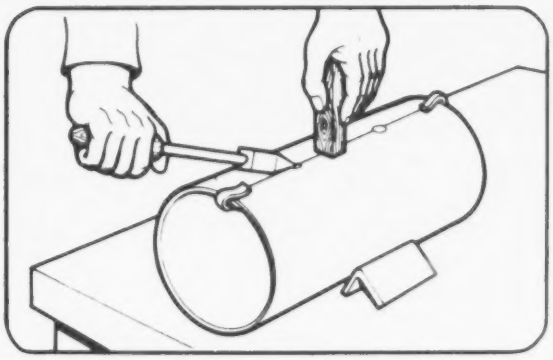
(e) Check temperature and tinning of bit.

(f) Apply bit to flux.

Note: Small spring pegs made from 3 mm or 5 mm mild steel sheet make useful clamps for light work.



(g) Pick up solder on point of bit.
Sufficient solder can be picked up on a well-tinned bit to apply a tack.

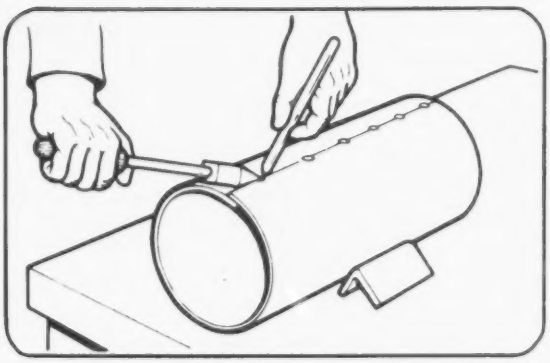


(h) Apply bit to edge of joint close to clamp. Allow sufficient time to enable solder to flow under lap.

(i) Repeat operations (g) and (h) to other end of joint.

(j) Repeat operations (g) and (h) at intervals. Sufficient tacks should be applied to hold joint close over its length.

(k) Remove clamps.



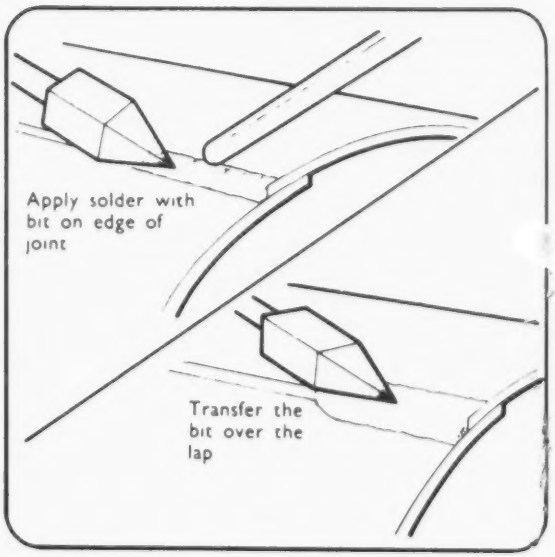
Soldering

(a) Re-flux joint.

(b) Check temperature and tinning of bit. Apply bit to flux.

(c) Apply bit to left hand end of joint.

(d) Apply solder to point of bit.



(e) Draw bit slowly along edge of joint. Hold joint, using a piece of wood if necessary. Allow sufficient time for solder to sweat through joint.

(f) Apply more solder as required.

(g) When soldering is completed, remove all traces of excess flux.

Note: (i) With large laps of 10 mm or so it will be necessary to transfer the bit over the lap in order to allow the solder to penetrate.

(ii) Observe, if solder begins to ridge and solidify immediately behind bit, the bit is too cold and must be re-heated. Non-penetration will also be apparent.

E I T B **Foundation Training – Unit 1**

TRAINING GUIDE No. 1B

TURNING
MILLING
WELDING
ELECTRICAL/ELECTRONIC

ENGINEERING INDUSTRY TRAINING BOARD **YT 11B**

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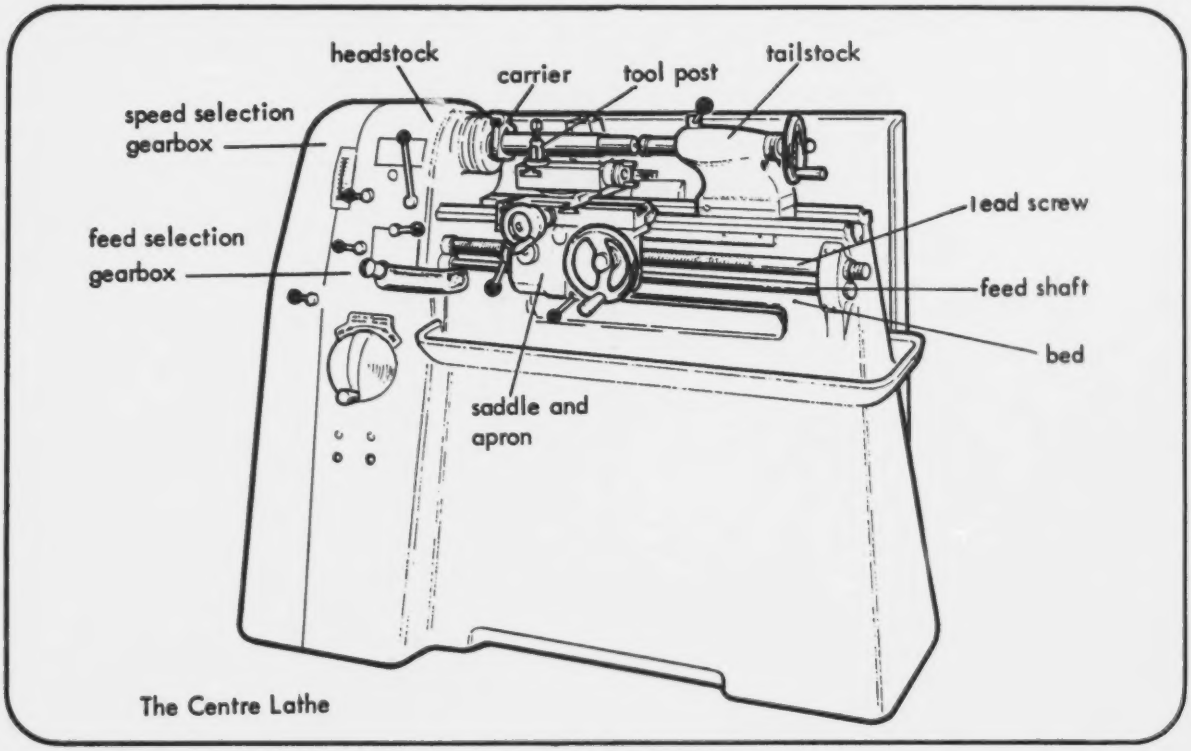
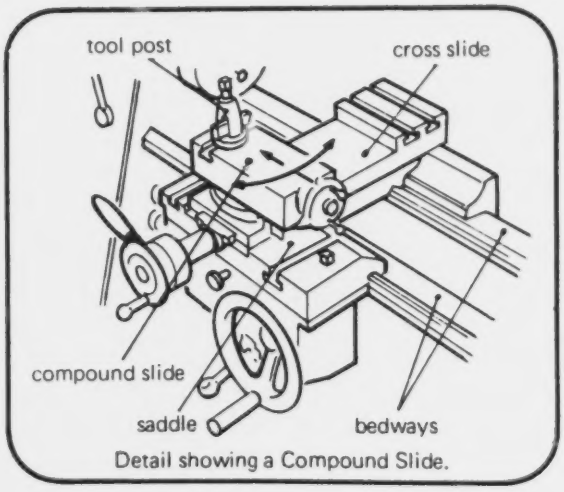
Lathes

Lathes are used for machining processes where the work can be conveniently turned and cut with a tool.



The Centre Lathe



Detail showing a Compound Slide.

The Centre Lathe

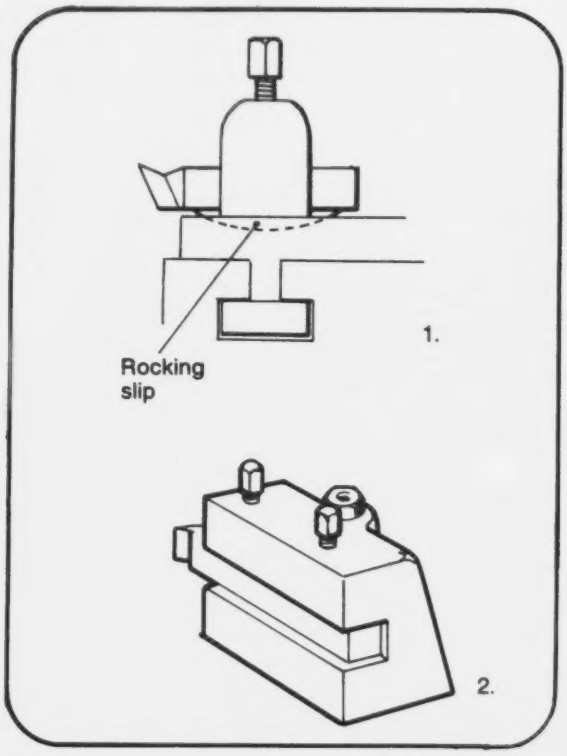
The centre lathe is so called because work can be held between centres, one in the headstock and one in the tailstock. On a centre lathe the tool can move along the bed (sliding) and across the bed (surfacing). The machine can also be used for cutting screw threads.

The left hand (headstock) centre can be replaced by a chuck or collet which holds and rotates the workpiece.

The machines on which you will be trained may vary in detail from those described but the principles of operation will be similar.

Important

For clarity some of the machines have been shown with guards removed. No machine should ever be operated unless it is properly guarded.



Tool mounting and holding

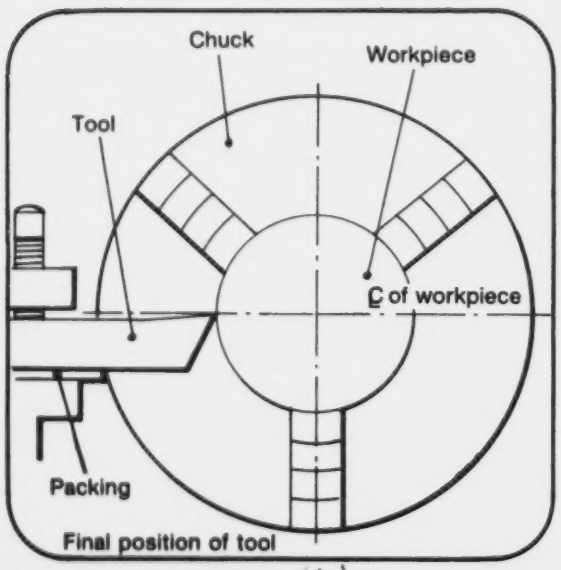
The tool post is designed to hold various tools and tool holders. Rigidity of the holder in its mounting and effective securing of the tools are most important for successful machining.

There must be provision for adjusting the height of the tool and its angle in relation to the work, and it must be capable of being locked firmly in position.

Types of tool posts (lathe)
Two of the most commonly used tool posts are illustrated.

1. Single tool holder, generally used for light work. A rocking slip mounted upon a spherically faced ring is provided in some of these holders to facilitate tool setting. It must be remembered that setting the tool out of its horizontal plane in this manner alters the effective rake and clearance angles.

2. Single tool holder, the tool is held quite independent of the main fixing bolt. Back tool posts are usually of this pattern, the height of the tool mounting being such that the bottom face of the tool, which is the cutting face in this instance, is brought in line with the axis of the workpiece.



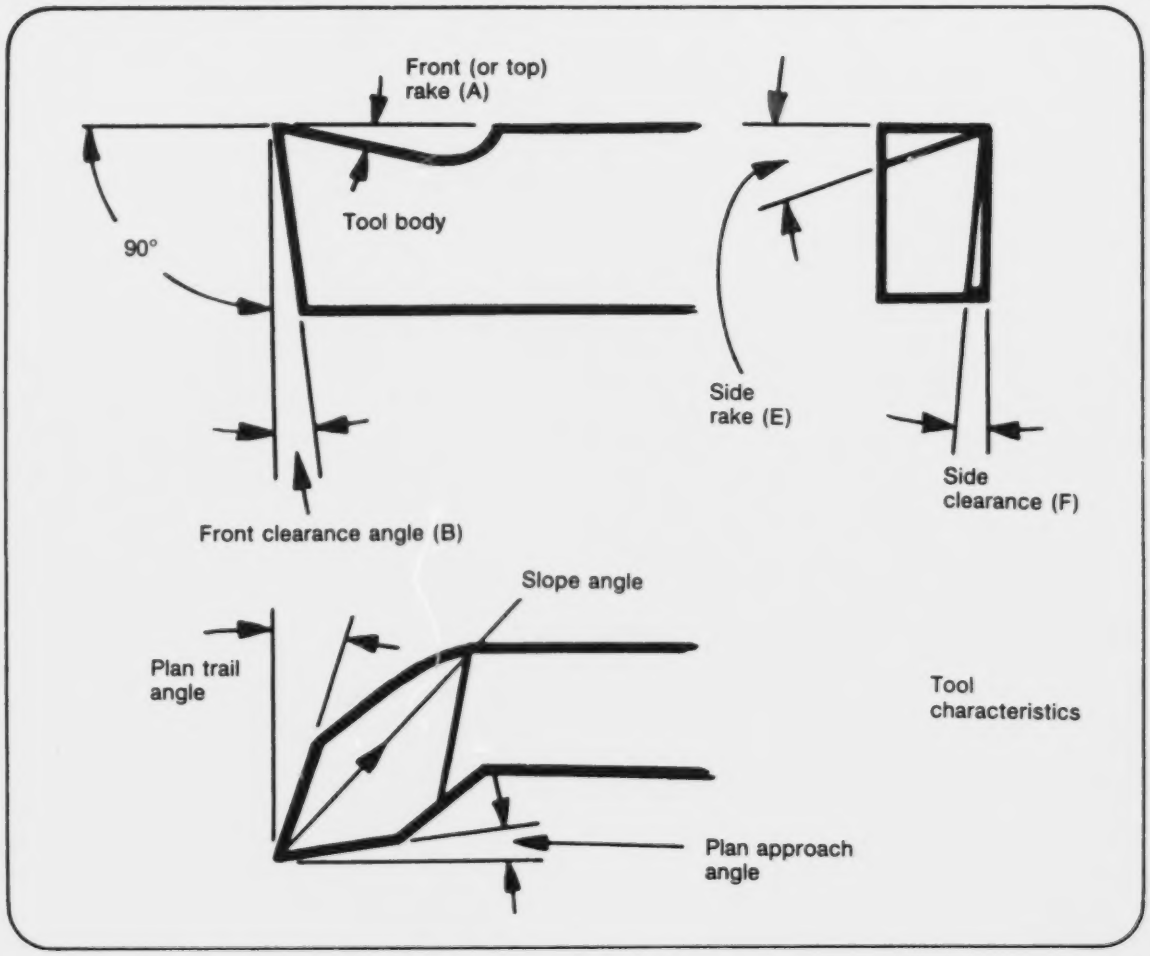
Adjust height by inserting packing strips under the tool until the correct measurement is obtained.

Note: If several thin packing strips are used, up to 0.4 mm should be added to the height. The tool will be pressed down to the correct height when tightened in the tool post. The width and length of the packing should be approximately the same as the tool.

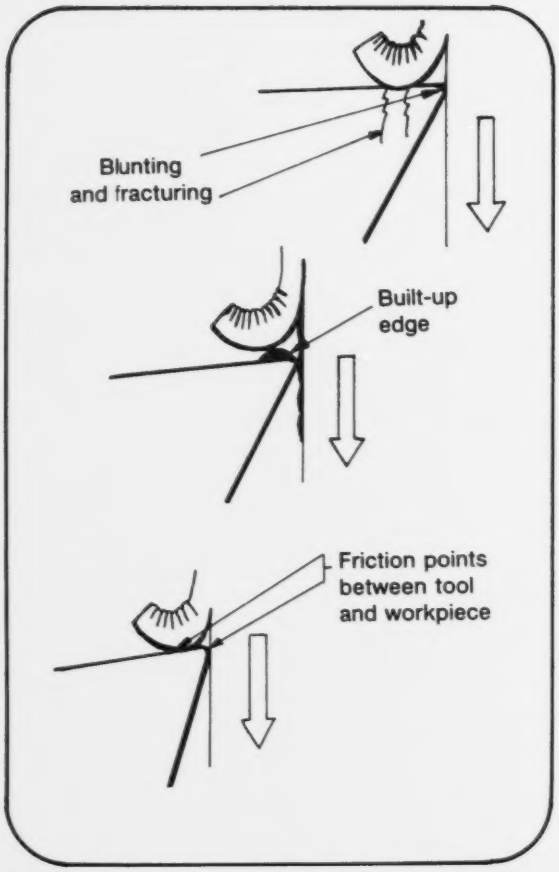
Tool geometry

Successful and accurate machining can only be accomplished by the use of the correct cutting tools, ground to the most suitable angles for the material being machined and used in a correct manner. The rake and clearance angles listed in the chart below are applicable to the varying materials to be machined. It will be noted from the chart that the top rake angle varies the most and it generally increases as the material gets softer. The front clearance angle varies the least and should be no more than necessary. If excessive clearance is allowed the point of the tool becomes too sharp, losing its necessary strength and heat dissipating area.

More clearance is often required, however, for boring tools.



Material	Front (or Top) Rake (A)	Front Clearance (B)	Side Rake (E)	Side Clearance (F)
Soft Steels	15°	8°	15°–20°	6°
Medium Steels	8°–10°	8°	12°–15°	6°
Hard Steels	5°	6°	6°–10°	6°
Cast Iron	8°	8°	10°–15°	6°
Brass & Bronze	1°	6°	0°–3°	6°
Copper	20°–25°	10°–15°	20°–30°	2°–5°
Aluminium	35°–55°	6°	10°–20°	1°–3°
Plastics	0° – 2°	6°	0° – 3°	6°



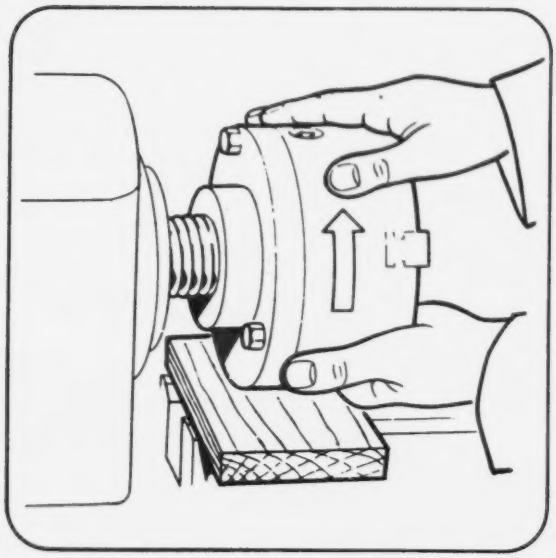
Coolant/cutting fluids

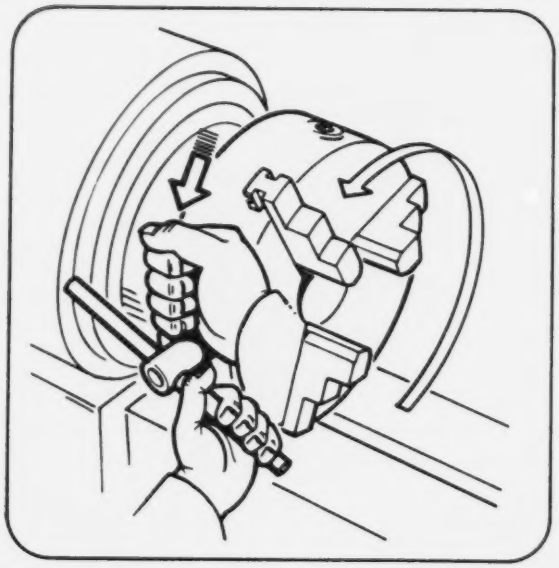
These are required to provide the following:
(a) Effective cooling of area around the tool point in order to prevent overheating which may cause the tool tip to become blunt or fracture.
(b) Effective cooling around the workpiece to stop it melting and causing a build-up on the tool point, which will affect its cutting efficiency.
(c) Effective lubrication in order that the friction of the chip passing over the surface of the tool is kept to a minimum.

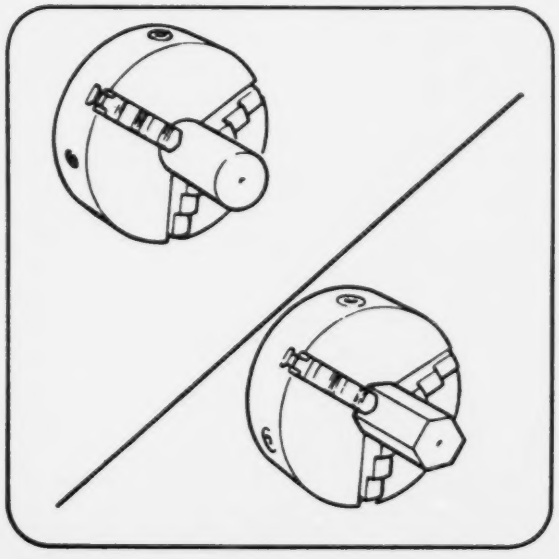
Note: Cutting fluids have the secondary purpose of "damping down" flying dust or fine swarf – a safety hazard to the health of the operator.

Sample lists of coolants and their application

Metal	Drilling	Reaming	Tapping
Mild steel	Soluble oil, Mineral lard oil	Mineral lard oil	Soluble oil, Lard oil
Tool steel (carbon high speed)	Soluble oil, Lard oil with sulphur	Lard oil	Sulphur base oil, Mineral lard oil
Alloy steel	Soluble oil, Mineral lard oil		Sulphur base oil, Mineral lard oil
Brass and bronze	Dry, Lard oil	Soluble oil	Dry, Soluble oil
Aluminium	Kerosene, Lard oil	Mineral lard oil	Lard oil, Soluble oil, Mineral lard oil
Malleable iron	Soluble oil	Soluble oil	Soluble oil
Cast iron	Dry	Dry	Small amount of mineral oil







Workholding and Setting

Mounting Chucks
Place a board across the lathe bed on which the chuck can be placed.

Screwed nose type

1. Fitting
(a) Clean spindle screw thread, location diameter and face.

(b) Clean chuck screw thread, location diameter and face.

(c) Engage low gear on stationary machine.

(d) Screw chuck to spindle nose. Use only sufficient force to lock chuck in place.

2. Removal
(a) Engage low gear on stationary machine.

(b) Insert chuck key into chuck.

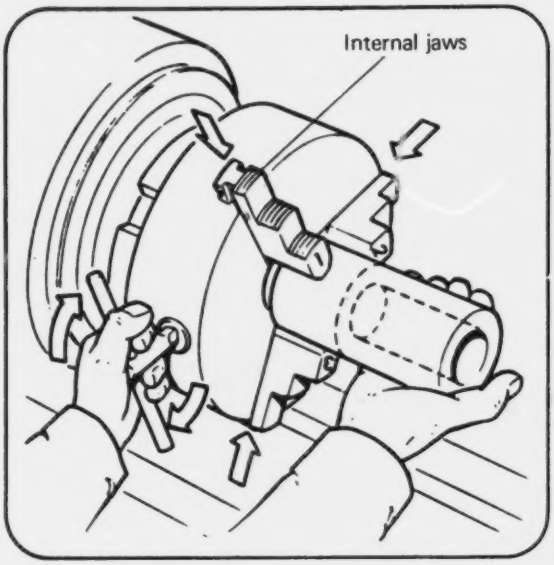
(c) Hold key in chuck and strike key with heel of palm.of hand or soft hammer.

(d) Remove chuck and place in storage.

> **Safety**
> Isolate machine before commencing to remove or fit chuck.

The Three Jaw Chuck
The advantage of a three jaw universal chuck is that the jaws are self centering, enabling the work to be set centrally. The majority of chucks have two sets of jaws for holding internal and external diameters. Only perfectly round work, or work with equally spaced flats divisible by three, (e.g. hexagon bar), should be held in a three jaw chuck.

> **Safety**
> When using 3 or 4 jaw chucks ensure that the chuck key is removed before the machine is switched on.



Clamping on External Diameters – Locating and clamping a shaft

1. Position shaft

Safety
Check that machine is isolated.

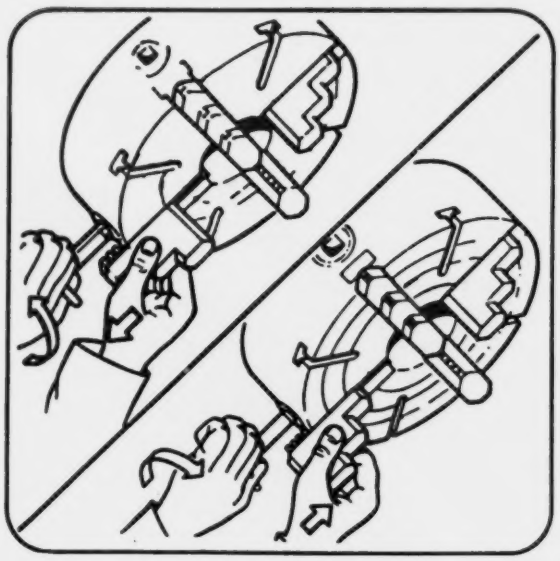
(a) Open chuck jaws, visually comparing opening until just larger than workpiece diameter.

(b) Position workpiece in chuck with minimum amount protruding to allow machining to be completed.

2. Clamp shaft in chuck
(a) Hold workpiece in position and tighten chuck jaws allowing workpiece to pull central and parallel to jaws.

(b) Tighten chuck jaws securely.

Note: Position shim to protect finished diameters.



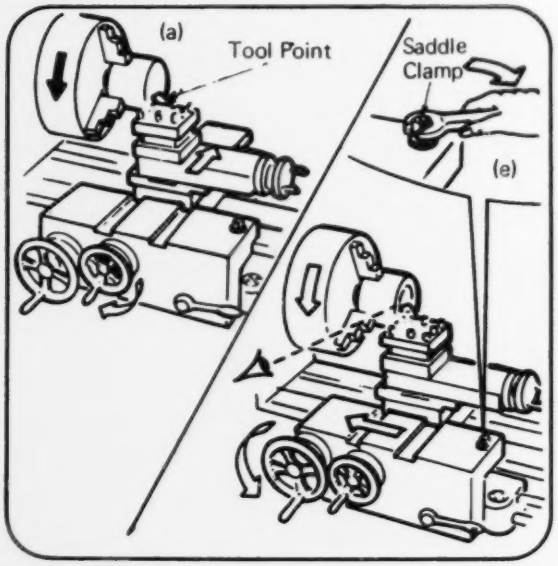
The Four Jaw Chuck
The four jaw chuck has jaws which are reversible and are adjusted independently. The advantage of a four jaw chuck is that both symmetrical and irregular shaped work can be held and set either concentrically or eccentrically. The disadvantage of this chuck is that each workpiece must be individually set.

Turning Operations

Facing Off

Turning face to centre or bore

1. Preparation



(a) Set workpiece using appropriate workholding method, and check alignment.

(b) Set facing tool in toolpost.

(c) Set speed and feed.

2. Touch tool to the face

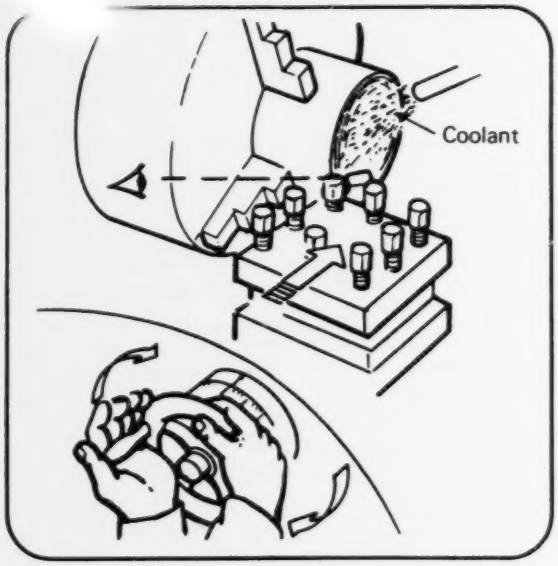
(a) Using saddle and cross-slide, position the cutting point of the tool just clear of the face to be machined.

(b) Start machine spindle.

(c) Wind saddle to move the tool towards the face of the workpiece. Control the approach by watching the decreasing gap between tool and face. Stop saddle movement when tool lightly contacts face.

(d) Using the cross-slide clear the tool from the face.

(e) Clamp saddle to lathe bed.



3. Machine face

(a) Zero dial on compound slide.

(b) Zero angular setting of compound slide.

(c) Apply required cut using compound slide.

(d) Turn on coolant.

(e) Using the cross-slide, hand feed the tool across the face of workpiece. Maintain an even feed rate.

(f) When the cutting point clears the centre of the bar, withdraw cross-slide and apply further cuts until the face is cleaned up.

Note: Automatic cross feed can be used.

(g) Stop machine spindle, turn off coolant, check face for finish and flatness.

(h) Determine whether tool setting is correct.

Note: Where a large amount is to be removed from the face, take roughing cuts to leave approximately 0.75 mm for final machining.

Facing to length

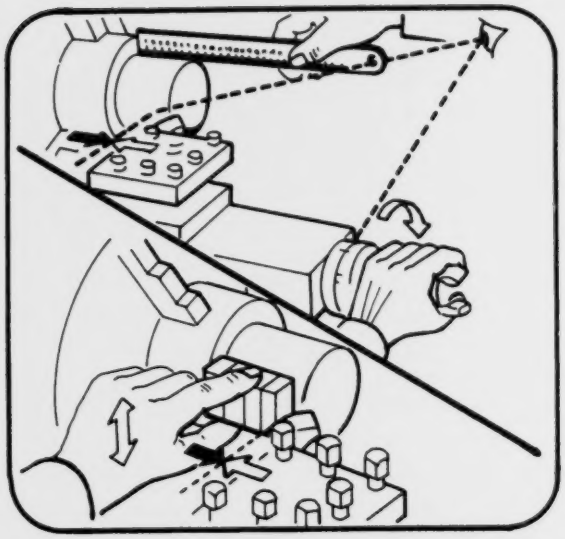
1. Facing length from shoulder
(a) Rough turn face to leave approximately 1 mm on required length.

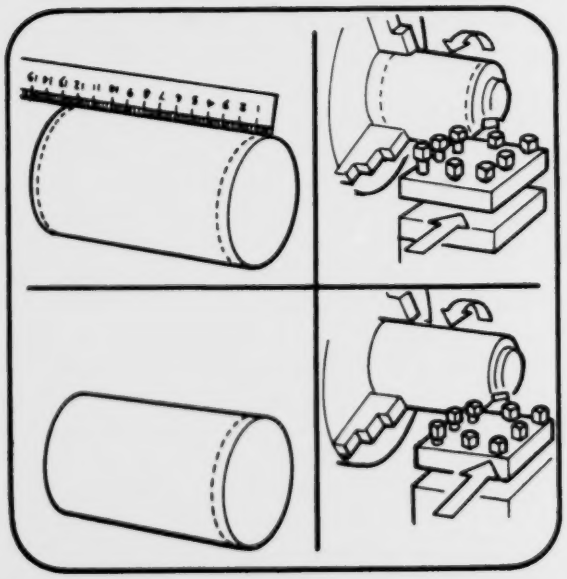
(b) Stop machine spindle and check length using appropriate measuring instrument.

(c) Set finish cut using compound slide.

(d) Face to length.

(e) Remove sharp edges.





Alternatively
(a) Rough turn face to leave approximately 1 mm on required length.

(b) Stop machine spindle.

(c) Select end bar or build up slip gauges including protector slips to length required.

(d) Hold face of end bar or the slip gauges on to face of shoulder.

(e) Slide slip gauges backwards and forward on face.

(f) Position tool to lightly touch slip gauges. Remove gauges.

(g) Face to length.

(h) Stop machine spindle and check length to shoulder.

Facing overall length

1. Machine first face
(a) Check length of workpiece noting amount of metal to be removed.

(b) Set workpiece true in appropriate work-holding device.

(c) Rough and finish turn face of workpiece, removing approximately half the excess length of metal.

(d) Remove sharp edges.

(e) Stop machine spindle and remove workpiece from machine.

2. Machine second face
(a) Check length noting amount to be removed.

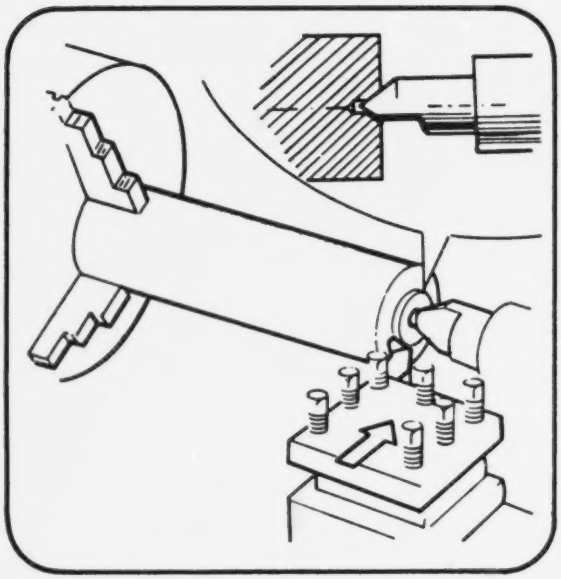
(b) Re-set workpiece to machine opposite face.

(c) Touch tool to face.

(d) Set depth of cut on compound slide index.

(e) Rough and finish turn face.

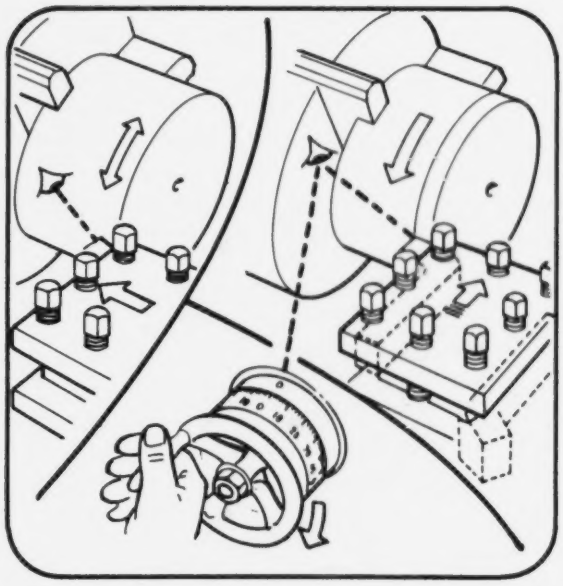
(f) Remove sharp edges.



(g) Stop machine spindle, remove workpiece and check length.

Note: (i) If rear end of workpiece is accessible the length can be checked without removing workpiece from the machine.

(ii) If facing the end of a shaft located on centres a half centre should be engaged in the tail-stock.



Turning a Diameter up to a Shoulder

1. Preparation
(a) Set workpiece true in chuck

(b) Set facing and turning tools in toolpost.

(c) Set speed and feed to suit material and required surface texture.

2. Touch tool to face
(a) Position facing tool to front station.

3. Machine face.

4. Touch tool to workpiece diameter
(a) Position turning tool to front station.

(b) Wind cross-slide to position point of tool clear of diameter of workpiece.

(c) Unlock saddle and wind along, to position tool just within length of workpiece.

(d) Start machine spindle.

(e) Wind cross-slide in, controlling feed rate by watching decreasing gap between tool and workpiece until tool marks a very fine line on the diameter.

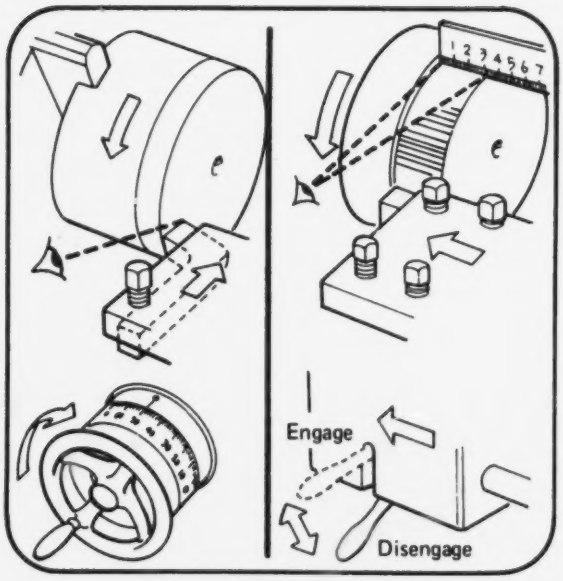
(f) Zero cross-slide index.

5. Rough turn diameter and length
(a) Wind tool clear of end of workpiece.

(b) Determine amount of metal to be removed to leave approximately 0.4 mm on diameter for finish machining.

(c) Apply cut using cross-slide index.

Note: Depth of cut will depend on amount of metal to be removed. If this is a large amount, several roughing cuts may be taken.

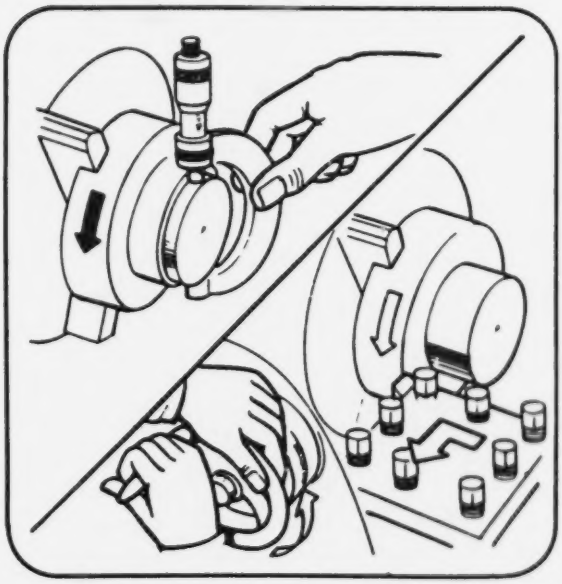


(d) Wind saddle to almost touch tool to end of workpiece.

(e) Engage feed.

(f) Control the length of machining by holding a rule near the shoulder, disengaging the feed when approximately 1 mm from the required length. Ensure rule is not in contact with rotating workpiece.

(g) Wind saddle back to original starting position. Apply further roughing cuts as necessary to bring the diameter within 0.4 mm of finished size.



6. Finish turn diameter and shoulder
(a) Wind tool clear of end of workpiece.

(b) Set finishing cut on cross-slide index.

(c) Engage traverse.

(d) When cut is approximately 3 mm along workpiece diameter, disengage traverse and stop machine.

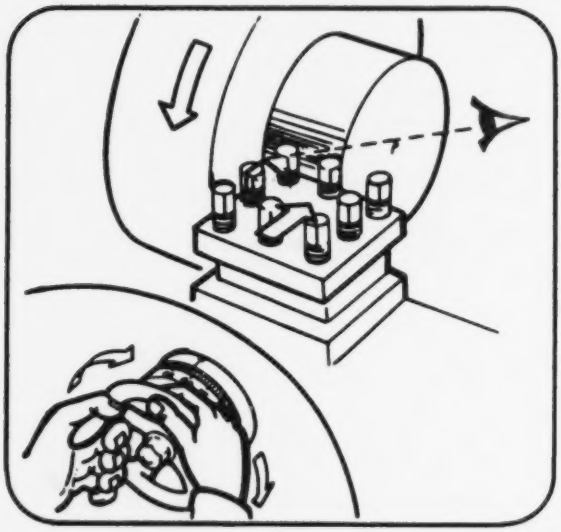
(e) Check diameter and adjust depth of cut if required.

(f) Engage feed and take cut.

(g) As tool approaches shoulder, disengage feed.

(h) Hand feed saddle to touch tool to shoulder.

(i) Hand wind tool out across face of shoulder maintaining an even feed rate.



7. Face shoulder to length
(a) Check length from end face to shoulder using appropriate measuring instrument.

(b) Set cut required using compound slide.

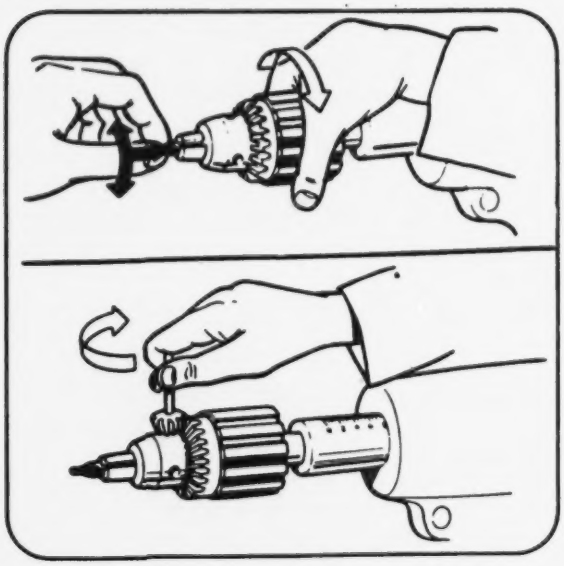
(c) Wind cross-slide in, maintaining an even feed rate.

(d) Decrease feed rate as tool nears diameter and watch for facing cut to blend in.

(e) Wind tool out to clear workpiece.

(f) Check length.

(g) Take further cut if required.



Centre Drilling

1. Preparation
(a) Face-off end of bar.

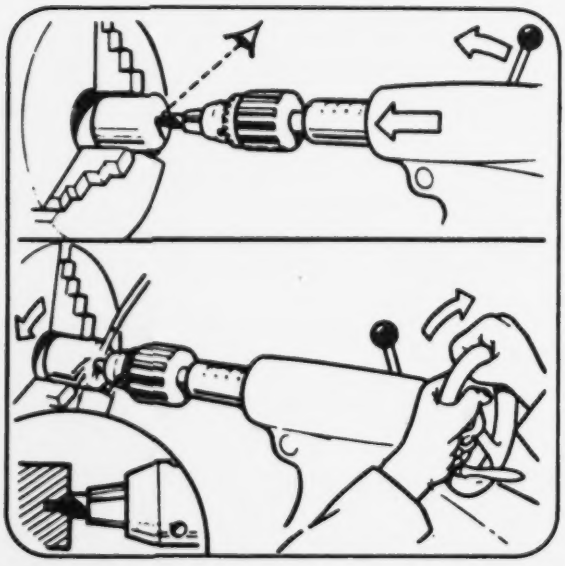
(b) Engage drill chuck in tailstock sleeve.

2. Engage centre drill in chuck
(a) Select correct size centre drill.

(b) Engage centre drill in chuck with minimum amount necessary protruding.

(c) Tighten chuck securely with correct key.

3. Centre drill workpiece face
(a) Slide tailstock to position point of centre drill close to workpiece face.



(b) Clamp tailstock in position.

(c) Set speed and start machine spindle.

(d) Advance tailstock sleeve until point of centre drill touches workpiece.

(e) Apply good flow of coolant.

(f) Carefully advance centre drill into workpiece face to full depth of chamfer.

Note: Swarf tends to build up in flutes of small centre drills so they should be withdrawn frequently and the flutes cleared with a brush.

(g) Withdraw centre drill and tailstock when depth is reached.

Drilling Holes

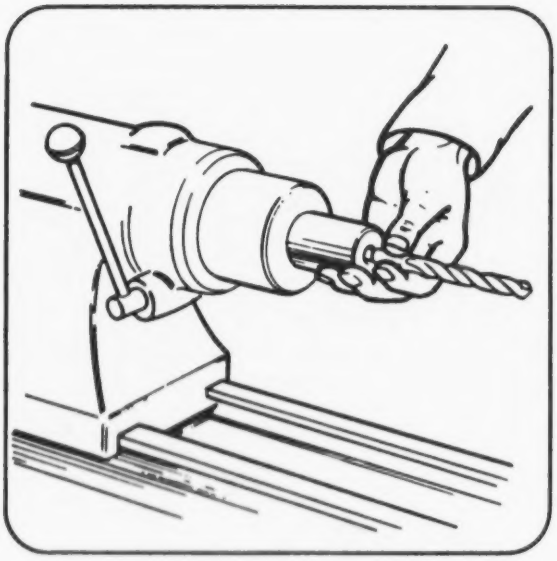
1. Mount the workpiece.
(a) Clean the chuck jaws.

(b) Mount the workpiece in the chuck.

(c) Align if required.

(d) Tighten the chuck.

(e) Re-check for concentricity.



2. Face end and rough turn.

3. Centre drill workpiece.

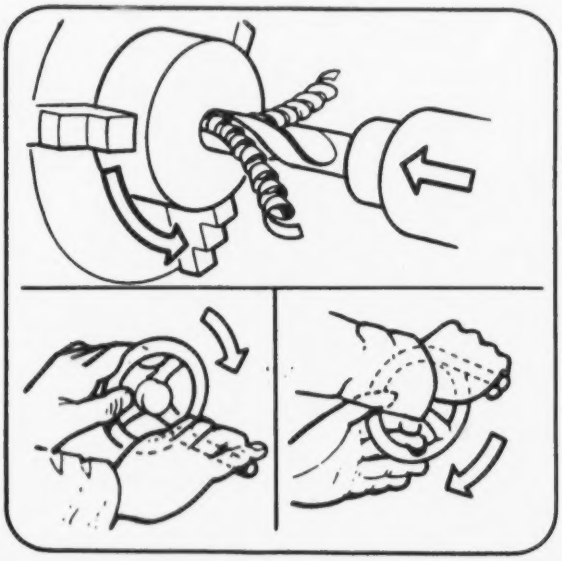
4. Mount the drill in the tailstock.
(a) Select the required drill.

(b) Mount the drill in the tailstock, using taper sleeves as necessary.

(c) Retract tailstock spindle as far as possible without ejecting drill.

> **Safety**
> Hold the drill on the plain diameter when mounting.

5. Position tailstock to workpiece
(a) Loosen tailstock on machine bed.



(b) Slide forward to almost touch drill point to workpiece.

(c) Tighten tailstock to bed.

6. Drill hole through
(a) Apply firm even pressure to tailstock hand wheel to feed the drill into the workpiece.

(b) Feed in gently until drill is cutting its full diameter.

(c) Apply coolant.

(d) Relieve handwheel pressure frequently to break up swarf.

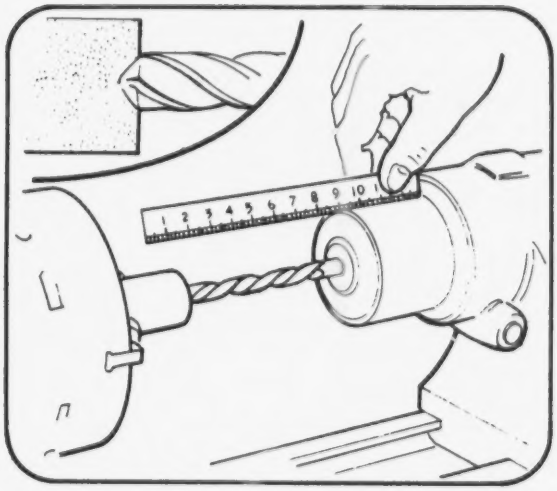
Note: If the drill has been ground correctly, and is cutting efficiently, the swarf of some metals will emerge from the flutes of the drill as two equal spirals.

Safety
Keep hands clear of swarf.

(e) Just before break-through a drop in resistance to the feed will be felt, immediately ease the pressure on the handwheel. This will allow a cleaner break-through and will minimise the chance of damage to the drill.

(f) Ease the drill fully through.

Note: When drilling holes of a diameter over 30 mm it is advisable to use two drills, e.g. size of hole required = 44 mm, use drill sizes 25 mm and 44 mm. When drilling holes in preparation for reaming use a drill 0.4 mm under finished hole size.



7. Drill hole to depth
(a) Apply firm even pressure to tailstock handwheel to feed the drill into the workpiece.

(b) Stop feed as drill begins to cut full diameter.

(c) Note calibration on tailstock sleeve or measure length of sleeve protruding from tailstock.

(d) Add depth of hole required to reading obtained.

(e) Drill hole.

(f) Note calibration or rule reading for required depth.

8. Withdraw the drill.
(a) Retract tailstock sleeve.

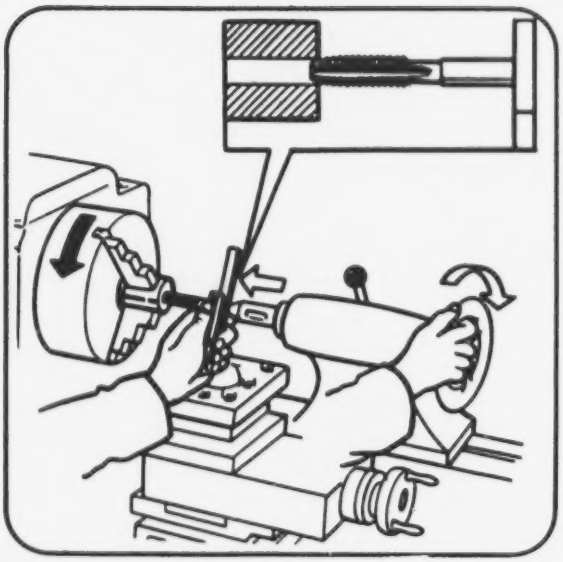
(b) Unlock tailstock and move to end of machine bed.

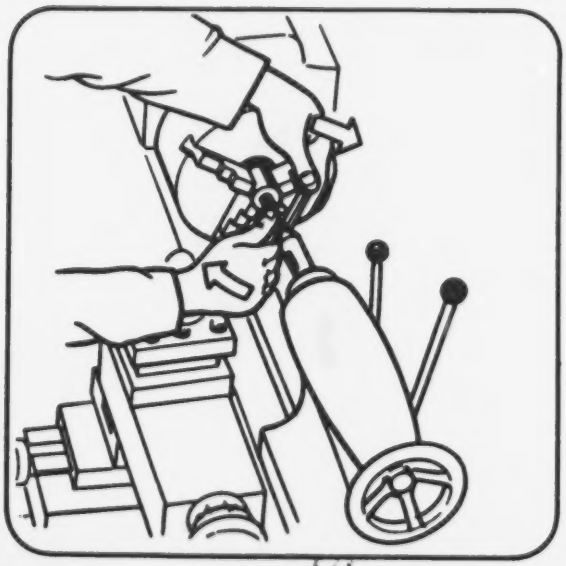
(c) Remove drill from tailstock.

(d) Stop the machine.

Tapping Holes

When a tapped hole is required the size of the tap is given, i.e., "1 hole drilled and tapped M10". Standard charts are used to obtain the hole size which is required for a given size of tap.
i.e., To tap M10 the hole must first be drilled with a 8.5 mm drill.





Tapping through holes

1. Face off end of workpiece

2. Centre drill

3. Drill correct size and depth for tapping

4. Set for tapping
(a) Switch off machine.

(b) Select suitable tap wrench and fit tap.

(c) Mount spring loaded centre in tailstock.

(d) Apply suitable lubricant to tap.

(e) Insert tapered end of tap into drilled hole.

(f) Hold tap and wrench in left hand, square up visually.

(g) Bring up tailstock. Locate spring loaded centre into centre hole in end of tap, clamp tailstock to bed.

(h) Wind in spring loaded centre to apply pressure on the tap.

Note: A centre is used to ensure that the tap enters the hole squarely. If a spring loaded centre is not readily available an ordinary lathe centre may be used and the pressure maintained by winding in the centre, at the same time turning the tap wrench.

5. Tap hole
(a) Turn tap wrench in a clockwise direction approximately two full revolutions.

(b) Reverse tap approximately half revolution. This will break the chip and stop the tap from clogging or jamming in the hole.

(c) Repeat the process of turning tap one to two full revolutions and reversing for half revolution until hole is tapped through, ensuring at all times that the tailstock centre is in contact with the tap.

6. Check thread
(a) Clean swarf from tapped hole.

(b) Check thread with screw plug gauge.

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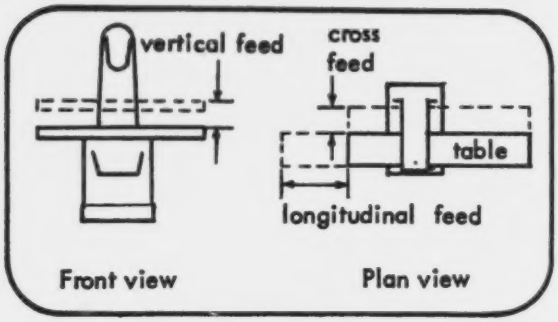
Milling Machines

The milling machine is used to machine plane surfaces. The operation of the milling machine differs from that of the lathe in that the cutting tool rotates in one position and the workpiece is moved to provide the feed.

Horizontal Milling Machine

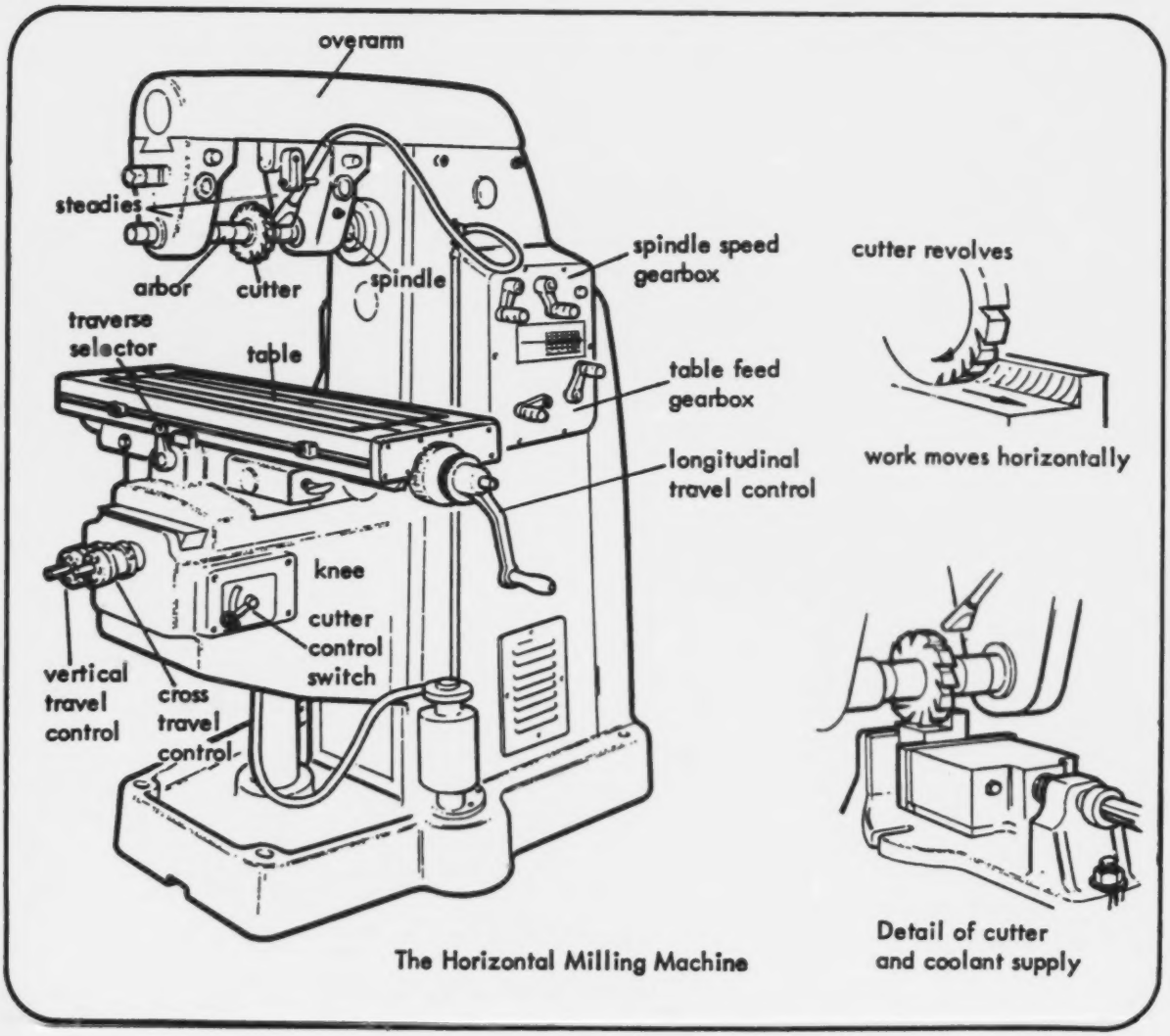
In this machine, the spindle driving the arbor which carries the cutting tools is horizontal. (Attachments can sometimes be fitted to convert the machine for vertical milling.)



In the Milling Machine illustrations cutter guards have been omitted for clarity.

Specification

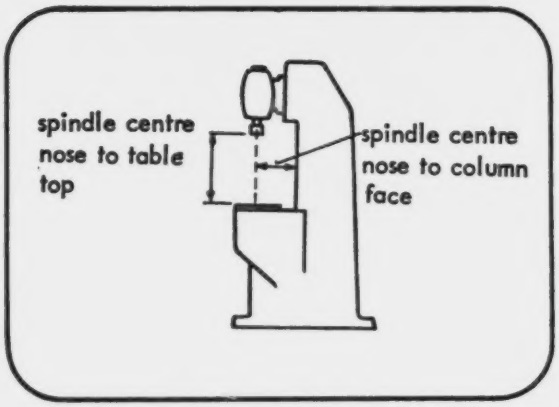
The range of speeds and feeds; the maximum and minimum vertical traverse of the knee; the maximum and minimum cross traverse; and the length of table (overall and working)



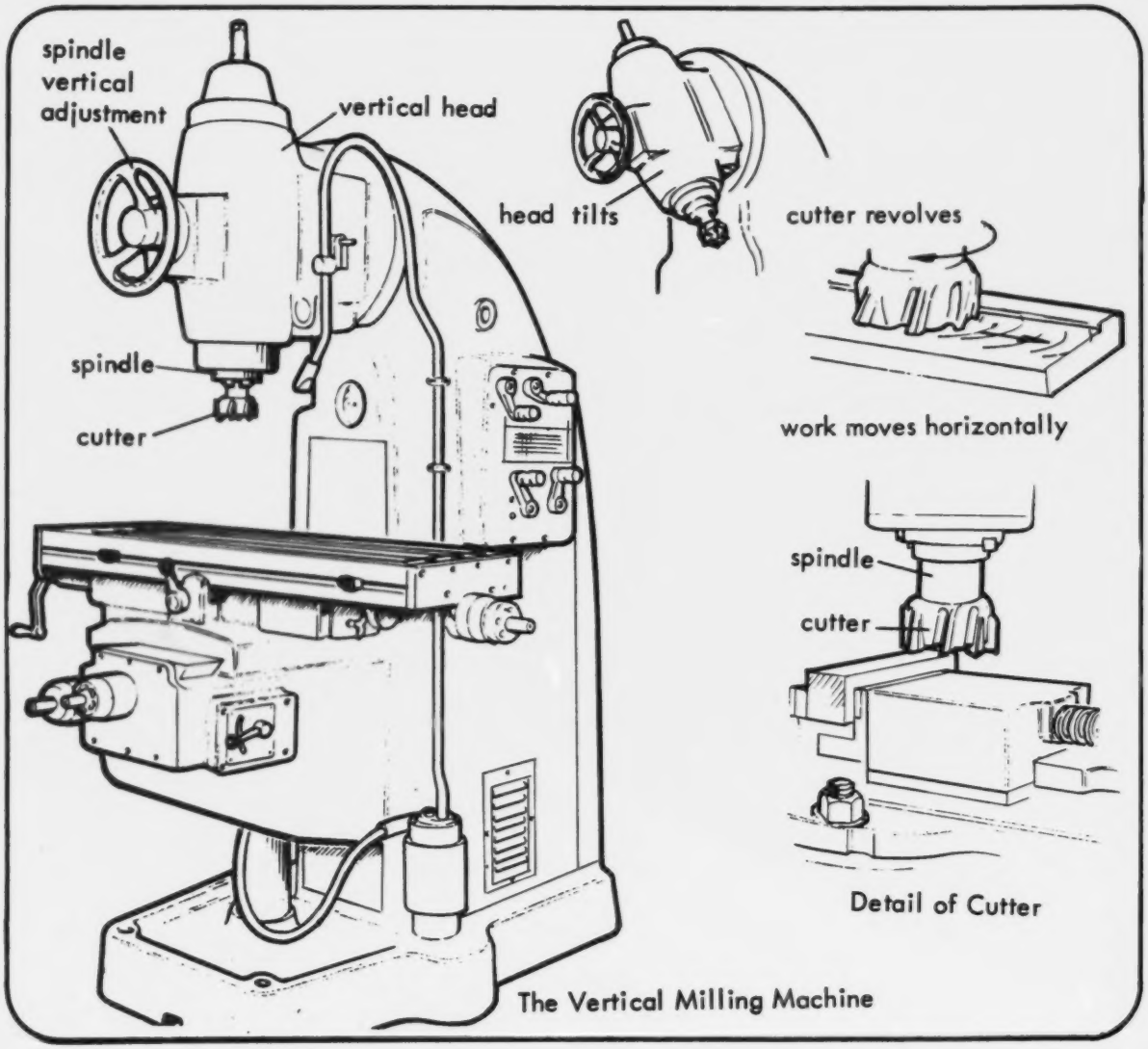
The Horizontal Milling Machine

Vertical Milling Machine
In this machine, the spindle carrying the cutters is vertical and forms a right angle with the face of the table.

In some cases, attachments can be fitted to convert the machine for horizontal milling and boring.

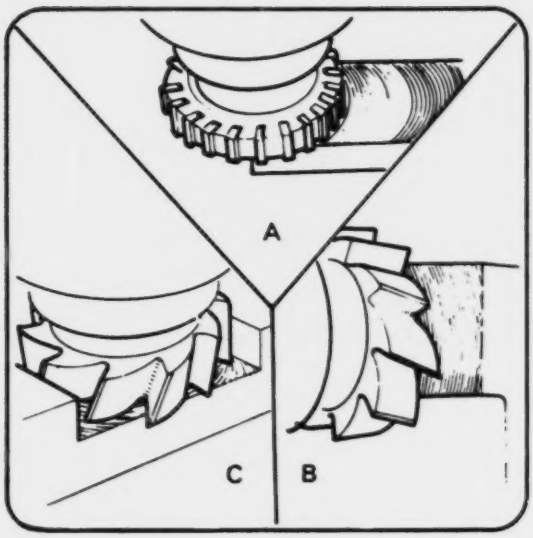


Specification
As for the horizontal machine, plus: the spindle centre nose to the table top; and the spindle centre nose to the column face.



The Vertical Milling Machine

12A



Types and Application of Milling Cutters

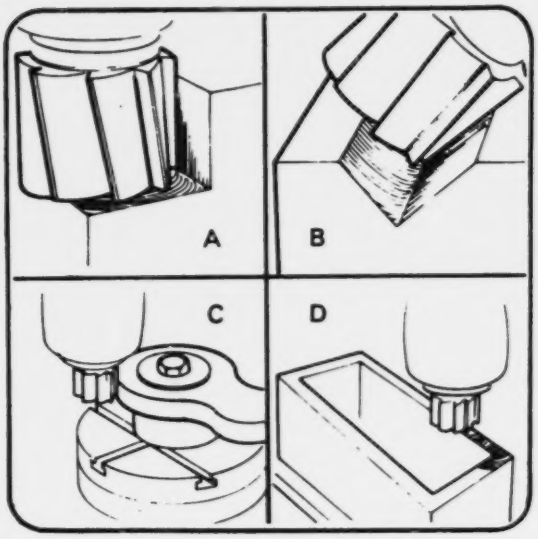
Face Mill
Face mills are used to produce flat surfaces:

1. Facing the top of a workpiece on a vertical mill, (A).

2. Facing the end or edge of a workpiece on a horizontal mill, (B).

3. Milling shallow steps in workpiece, (C).

4. Roughing deep steps on workpiece.



End Mill
Typical applications:

1. Milling a shoulder, (A)

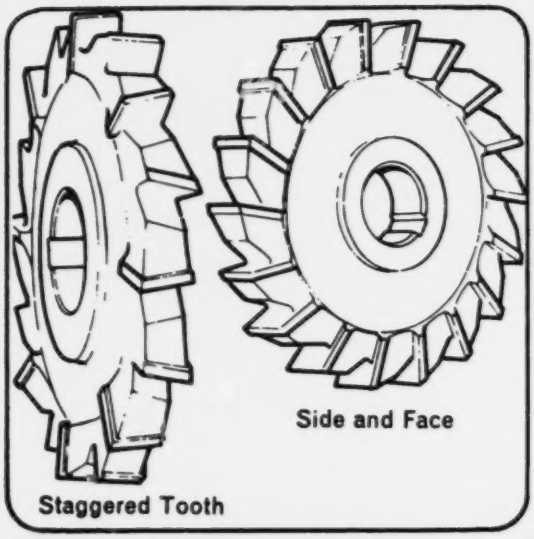
2. Milling angular faces, (B)

3. Milling internal and external profiles, (C)

4. Milling flat edges or faces, (D).

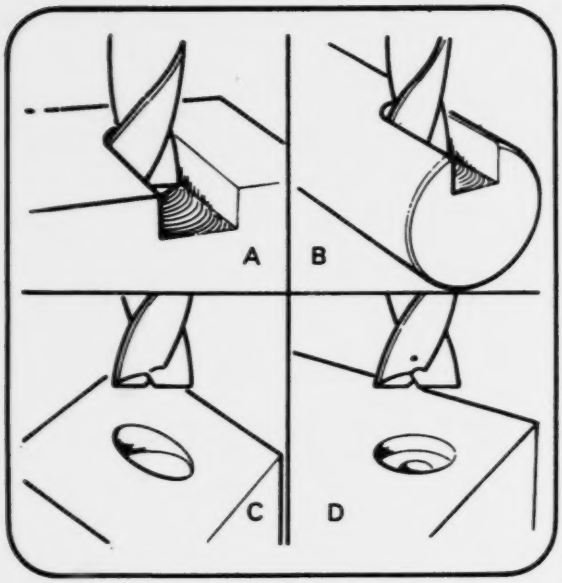
Cutter selection
1. Select smallest diameter cutter to cover face when milling to a shoulder.

2. Select the largest convenient diameter cutter to machine a flat face with the cutter face.



Side and Face Cutters
Side and face cutters are disc-like cutters with teeth which cut on each side as well as on the periphery. Sometimes a cutter is made to cut on one side only; this type is called a half side milling cutter. Another type has alternative teeth on each side of the cutter; this is a staggered tooth cutter.

Slotting Cutters
Slotting cutters are narrow cylindrical cutters very similar to the side and face type, but with teeth on the periphery only. The teeth are usually straight on cutters up to 20 mm wide, while wider cutters have spiral teeth.



Slot Drills
Typical applications:

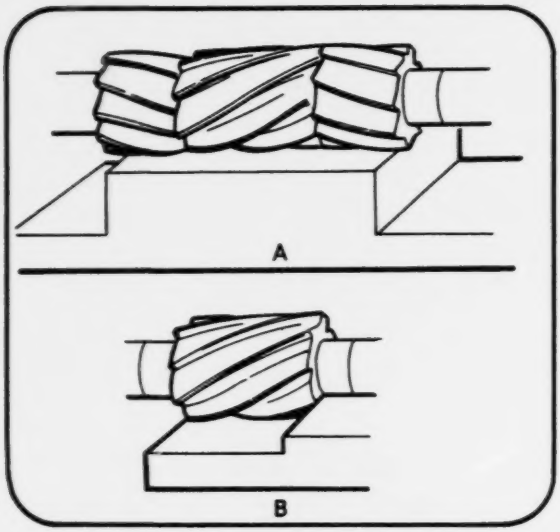
1. Milling slots, (A)

2. Milling keyways, (B)

3. Milling a flat seat on angular or curved surface, (C)

4. Milling small counter-bores or spot facing, (D)

5. Re-aligning incorrectly positioned holes.



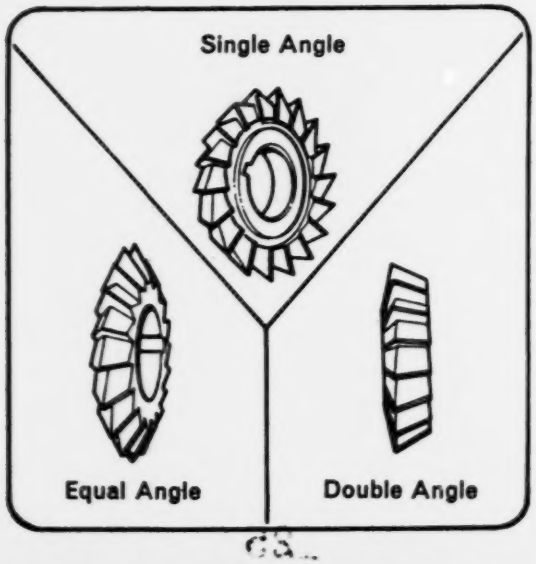
Roller or Slab Mill
Typical applications:

1. Milling the top face of a workpiece, (A)

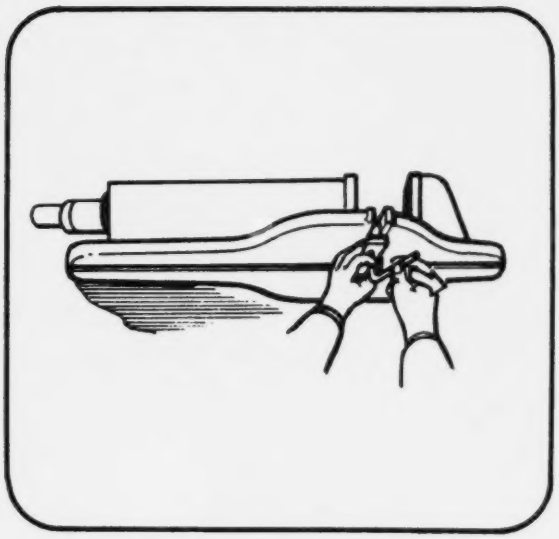
2. Milling to a shoulder, (B)

Cutter selection
1. Select the smallest convenient diameter cutter

2. Select a pair of interlocking cutters of exactly the same diameter and with opposite spiral angles if a wide face is to be machined.



Angle Cutters
Angle cutters are similar to small side and face cutters except that one or more sides of the teeth are ground at an angle to the axis.



Workholding—Setting and Clamping

Setting Vice Parallel with Tenons

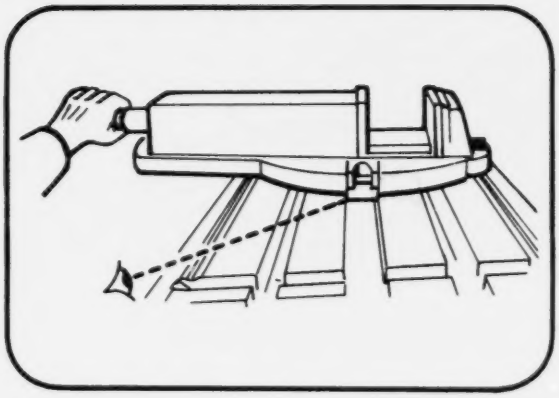
1. Tilt vice on to side on floor and insert tenons into tenon slots.

(a) Check tenons are clean and free from burrs.

(b) Clean tenon slots.

(c) Insert tenons in slots, and ensure cap screw holes in tenons are in line with tapped holes in vice.

(d) Insert cap head screws and tighten.



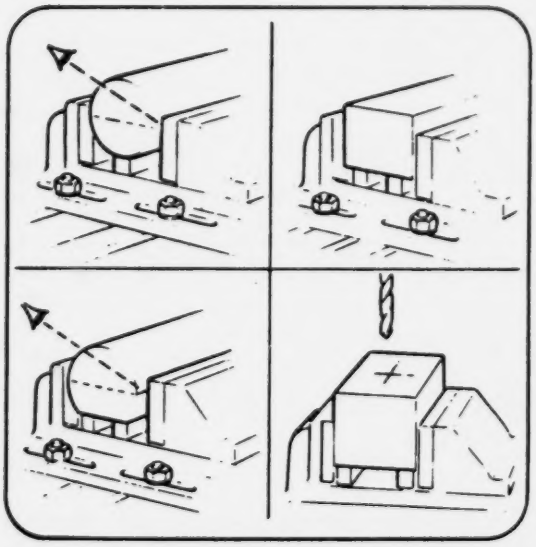
2. Position and clamp vice to table

(a) Lower vice to machine table with tenons approximately central to table slots.

(b) Engage tenons in table slots.

(c) Check vice to ensure a good seating on table, without movement.

(d) Tighten securing bolts.



Clamping Regular Shaped Workpiece in Vice

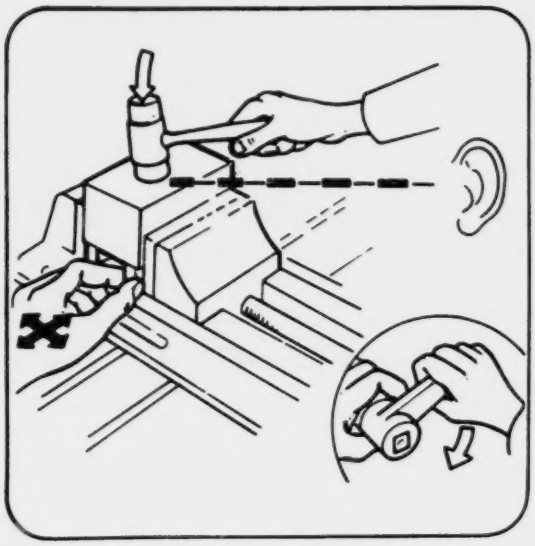
1. Position workpiece in vice

(a) Position maximum possible length and depth of workpiece in vice,ensuring cutters will not foul vice.

(b) If it is necessary to raise height of workpiece, position one parallel central if bottom of workpiece is round, or one parallel to each edge if bottom of workpiece is flat.

(c) Check that parallel will not foul cutters or measuring instruments.

(d) Visually check centre line of round workpiece is below top of vice jaw.



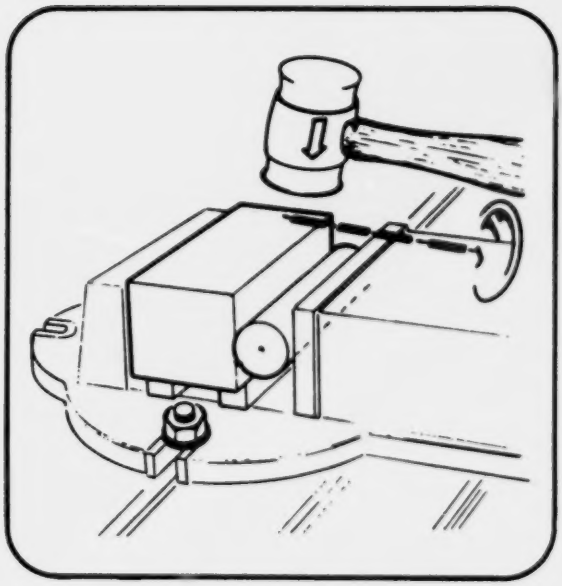
2. Seat workpiece and tighten vice
(a) Lightly tighten vice and tap workpiece down with soft hammer. A ringing sound is heard until workpiece is seated, when a dull thudding sound is heard.

(b) Check workpiece is correctly seated to vice bed with feeler gauge. If parallels are used ensure that they are tightly trapped.

(c) Tighten vice.

Milling Machine Operations

Milling a Block Square



1. Set workpiece in vice
(a) Select a pair of parallels of sufficient height to allow workpiece to be finished without cutter fouling vice jaws, but to hold maximum amount of block.

(b) De-burr block and clean vice jaws.

(c) Place smoothest side of block to fixed vice jaw.

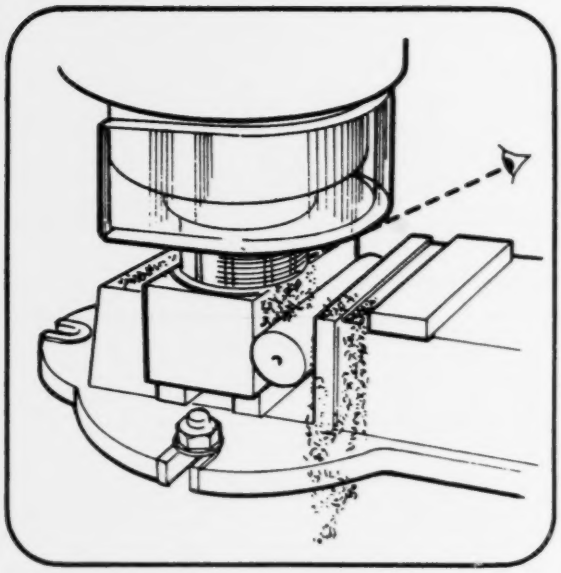
(d) Rest block on parallels, approximately central to length of vice.

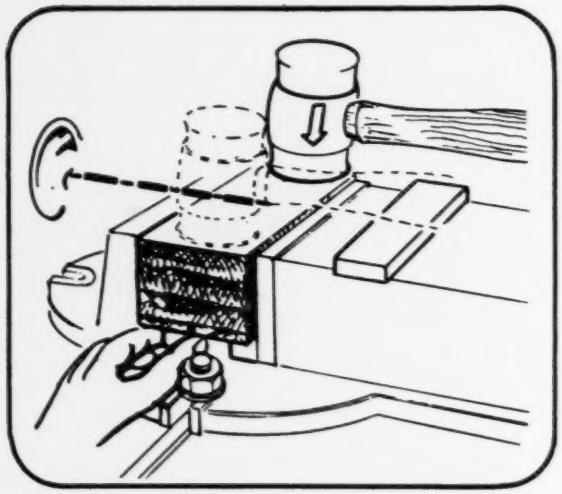
(e) Insert a round bar of suitable length, and approximately 20 mm diameter, between movable jaw and block, and approximately central to length of block in vice.

(f) Tighten vice and tap workpiece, to bring in same plane as parallels.

(g) Fully tighten vice and tap again.

Note: Block may not seat tight on parallels in its rough state.





Safety
Handle workpiece with care to avoid sharp edges and burrs.

Note: Bar is **not** used when machining the last side. When machining material such as phosphor bronze, the block should be rough machined on all four sides, leaving approximately 0.5 mm all round for finishing.

General Note: Although the illustrations show machining on a vertical milling machine, the same method is employed on a horizontal milling machine.

2. Machine first face
(a) Place a parallel on top of vice body to direct coolant back to table.

(b) Remove enough material to give a good clean face using plenty of coolant.

(c) Clear swarf from vice.

(d) Check surface finish.

3. Reset block in vice
(a) Remove block from vice.

(b) Clean vice and parallels, and remove burrs from block.

(c) Place machined side of block to fixed vice jaw, insert round bar and tighten as before.

(d) Check machined side of block with 0.04 mm feeler gauge, to ensure it is square to fixed vice jaw.

4. Machine second face

5. Check block
(a) Clear swarf and remove block from vice.

(b) De-burr block and wipe machined faces clean.

(c) Check the two machined faces with a square.

6. Machine third face
(a) Replace block in vice, one machined face to fixed vice jaw, other machined face on parallels.

(b) Insert bar and fully tighten vice.

(c) Tap block until it seats tightly on both parallels.

(d) Remove material to bring block to size.

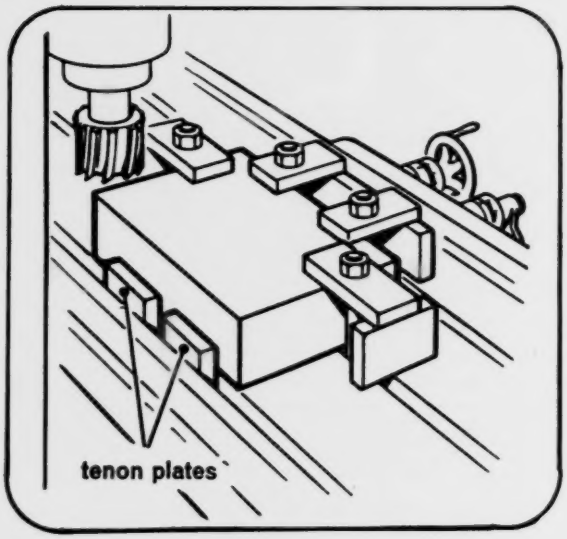
7. Machine fourth face
(a) Clean swarf, remove block and de-burr.

(b) Clean vice and parallels.

(c) Replace block with remaining un-machined side to cutter.

(d) Tighten vice and seat block tight on parallels.

(e) Machine to finished size.

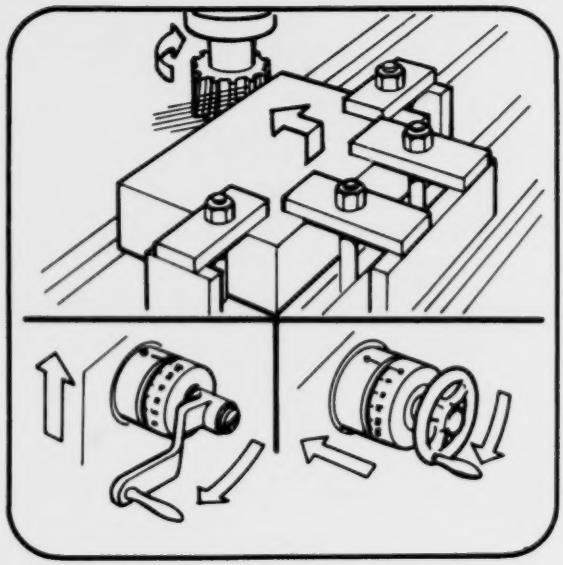


Milling a Shoulder

1. Mount workpiece
(a) Select a suitable workholding method, so that finished depth of cut can be obtained, without fouling workholding equipment or machine.

(b) Ensure that direction of cut is towards a fixed part of workholding, preferably to rear of machine, e.g. towards stops, clamps or fixed vice jaw.

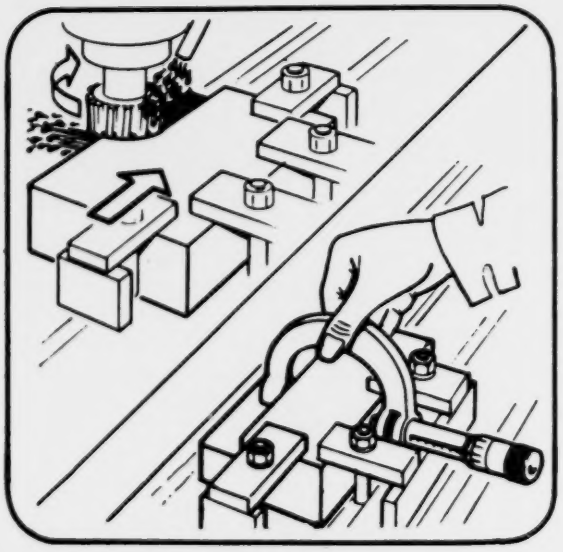
2. Select cutter (face or end mill) of sufficient diameter to cover full face of shoulder to be machined.



3. Position cutter to workpiece
(a) Start machine, and lightly touch periphery of cutter, to datum face of workpiece, and "zero" index.

(b) Wind table the required amount, less 0.25 mm to side face of shoulder, and lock slide.

(c) Lightly touch surface of workpiece with face of cutter, and "zero" index.



4. Cut out shoulder
(a) Adjust table to remove material in even cuts, using plenty of coolant.

(b) Check side of face of shoulder after a depth of approximately 3 mm has been reached.

(c) Check depth of shoulder, when within 0.5 mm of finished size.

(d) Adjust index for both side face and depth.

(e) Finish machine.

Note: If an end mill is employed, the full depth less 0.25 mm is first set, and the material removed by the side of the cutter.

This operation may also be performed on a horizontal milling machine, by setting up in the same manner and using an end mill or side and face cutter.

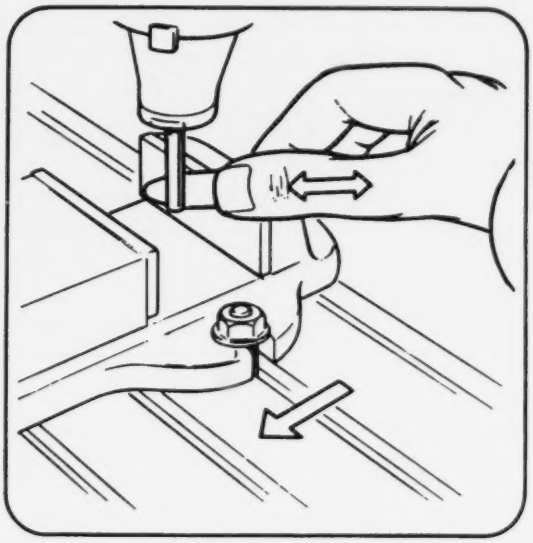
Milling a Slot

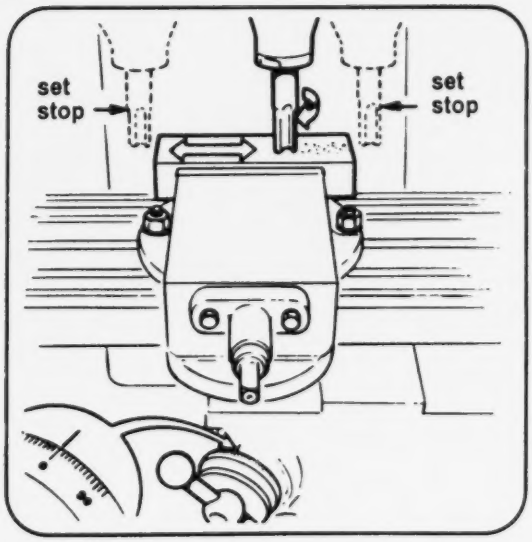
1. Set vice parallel.

2. Set for position of slot with setting bar

(a) Open vice jaws to give plenty of clearance for setting bar.

(b) Engage setting bar and position approximately central to vice.





(c) Check setting bar for concentricity.

(d) Raise table to enable setting bar to register on **fixed** vice jaw.

(e) Move table across until bar is within 1.5 mm of the fixed vice jaw.

(f) Insert a 0.03 mm feeler gauge, and carefully wind table across to trap feeler between bar and fixed vice jaw. Rock feeler gently until tightness is obtained.

(g) Zero index.

(h) Wind table back the required distance MINUS half the diameter of the setting bar, to give the correct centre position for the slot.

(i) Wind table at least 0.75 mm past the required setting and then wind it back to correct setting, to take up any free movement (backlash) in the leadscrew.

Note: Position of the slot may be central to the workpiece or a specific distance from one side.

3. Set workpiece in vice

(a) Ensure workpiece is free of burrs and the vice is clean.

(b) Seat on a pair of parallels (if necessary) to bring top of workpiece approximately 5 mm above vice jaws. Parallels to be tight after seating.

4. Set for depth and cutting slot

(a) Engage and check concentricity of cutter.

(b) Touch top of workpiece (with cutter revolving), marking the workpiece very lightly.

(c) Set vertical index at "zero".

(d) Set traverse stops at each end of table, to stop traverse when cutter has completely cleared workpiece at each end.

(e) Remove material in even cuts. Take cut from each end of workpiece alternately.

5. Check width, depth and position of slot

Safety
Switch off machine

(a) Check width of slot with slip gauges, after a depth of 1.5 mm has been obtained.

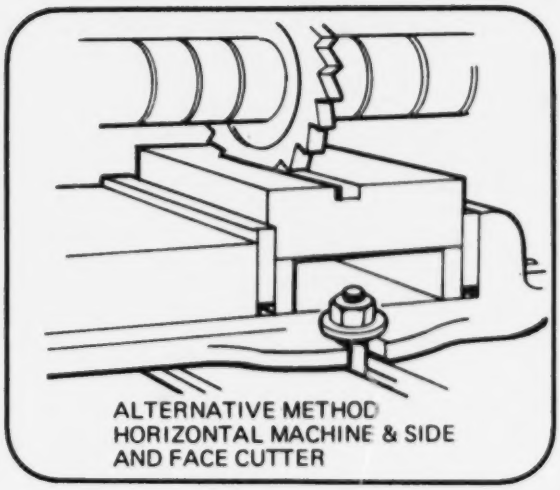
(b) Check position of slot with a micrometer or vernier after a depth of 3 mm has been obtained.

(c) Check depth of slot with depth micrometer or vernier when within 0.025 mm of full depth on index.

Safety
Cutter to be well clear of workpiece and stopped and any swarf removed before checking slot.

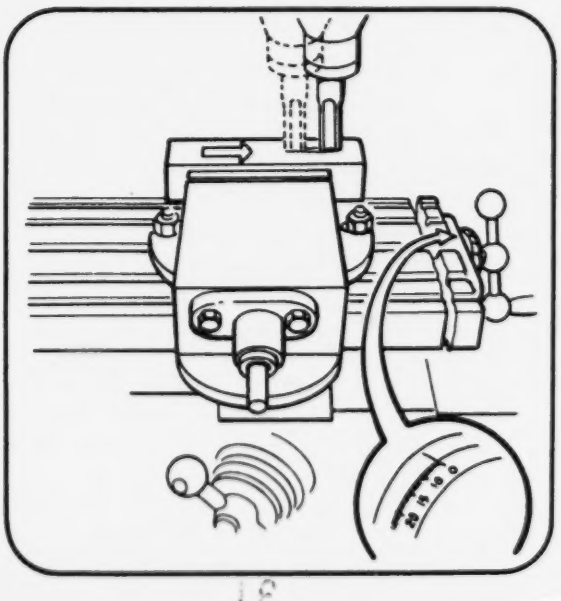
Note: It is possible to cut many types of slot on a vertical mill. The slot may not cover the whole workpiece, in which case an index reading must be taken or a stop set for the blind end.

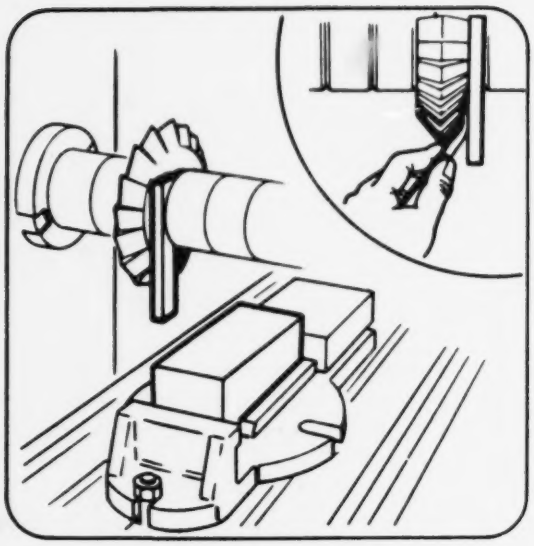
A stub arbor may be employed together with a side and face cutter. Round workpieces are usually set in the dividing head for this operation.



ALTERNATIVE METHOD
HORIZONTAL MACHINE & SIDE AND FACE CUTTER

Alternative Method
The operation may be carried out on a horizontal machine in the same manner, when a side and face or slot cutter is employed. Alternatively the workpiece may be clamped to the rear of the machine table, or to an angle bracket, and a slot drill mounted in the machine spindle.





Milling Vees on a Horizontal Machine
Vees are milled with an arbor mounted angle cutter.

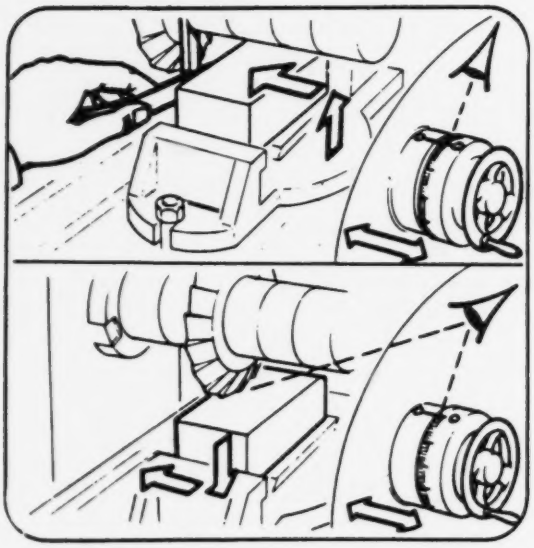
Milling Vees with Equal Angle Cutter
1. Mount cutter on arbor

2. Prepare arbor for cutter positioning
(a) Loosen arbor locking nut, and insert a small parallel bar, between cutter and collar.

(b) Ensure parallel protrudes approximately 6 mm below diameter of cutter.

(c) Tighten arbor locking nut.

(d) Check between cutter boss and parallel, with feeler gauge, to ensure a good seat.



Note: The cutter should be checked to ensure that the angles are ground equally about the centre.

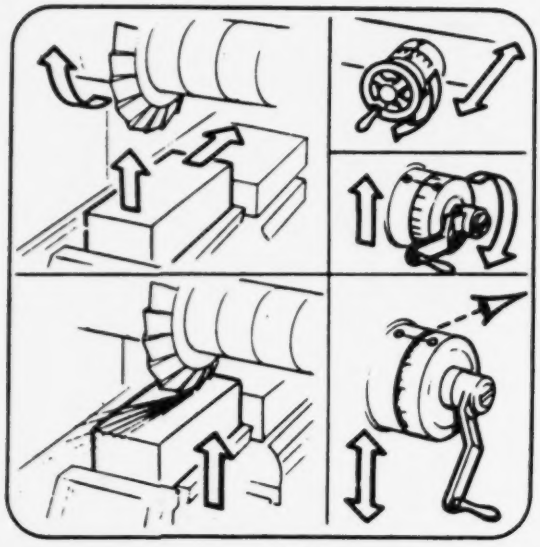
3. Position cutter to workpiece
(a) Bring parallel close to end of workpiece.

(b) Insert a feeler gauge between parallel and workpiece, and gently move across slide to lightly trap it.

(c) "Zero" the index. Drop table to clear parallel from workpiece.

(d) Wind cross slide the required distance to position centre of cutter. Reset index on "zero".

(e) Loosen arbor locking nut, remove parallel, and re-tighten.



4. Set cutter for depth
(a) Bring cutter over face of workpiece.

(b) Raise table (cutter revolving), to bring cutter so that points of cutter lightly mark workpiece.

(c) "Zero" index.

5. Cut the vee
(a) Remove material in even cuts, until about 6 mm depth has been reached.

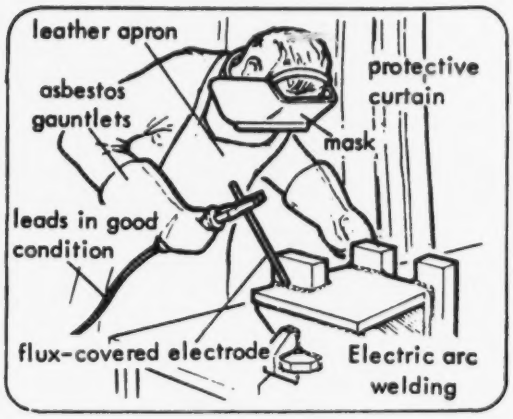
(b) Use plenty of coolant, remove swarf with brush, (cutter stopped).

(c) Reduce depth of cut after 6 mm depth has been reached.

Welding

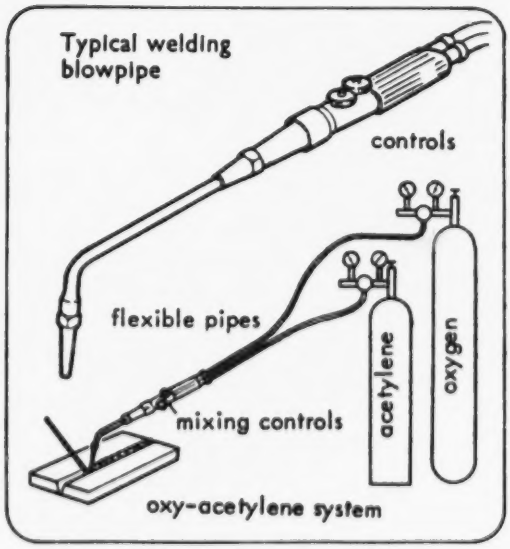
Welding is a process which provides a method of permanently uniting metals by the fusion of the base metals at the fusion surfaces.
The surfaces to be joined are heated to the molten state, additional molten metal being provided if necessary, from the fusion of a wire or rod to counteract either the losses of the base metals or to add to the thickness of the material at the weld.
Most ferrous, non-ferrous metals and alloys can be welded. The strength of the welded joint is practically that of the base metals and in some instances even stronger.
Two of the most widely used welding processes are:

1. Manual Metal-arc Welding
2. Oxy Acetylene Welding.



Manual Metal Arc Welding

An electric arc is a prolonged spark between two terminals of an electric circuit, the workpiece and an electrode. The spark is extremely hot, 6,500° F., and intense localised heat is produced. The electrode is coated with a suitable flux for cleaning and protection, and the electrode itself supplies the filler metal.



Oxy-Acetylene Welding

Oxygen and acetylene, when mixed in suitable proportions, give a flame which reaches a temperature of 6,000° F., in its hottest part.
In a high pressure system, the oxygen and acetylene are used from high pressure cylinders. The acetylene should be adjusted to working pressure first, and then the oxygen.

Identification of Welds

Details of welded joints on drawings are indicated by a system of symbols.

Weld Symbols

The basic requirements of B.S. 499, Part 2, schedule of symbols for welding comprise:

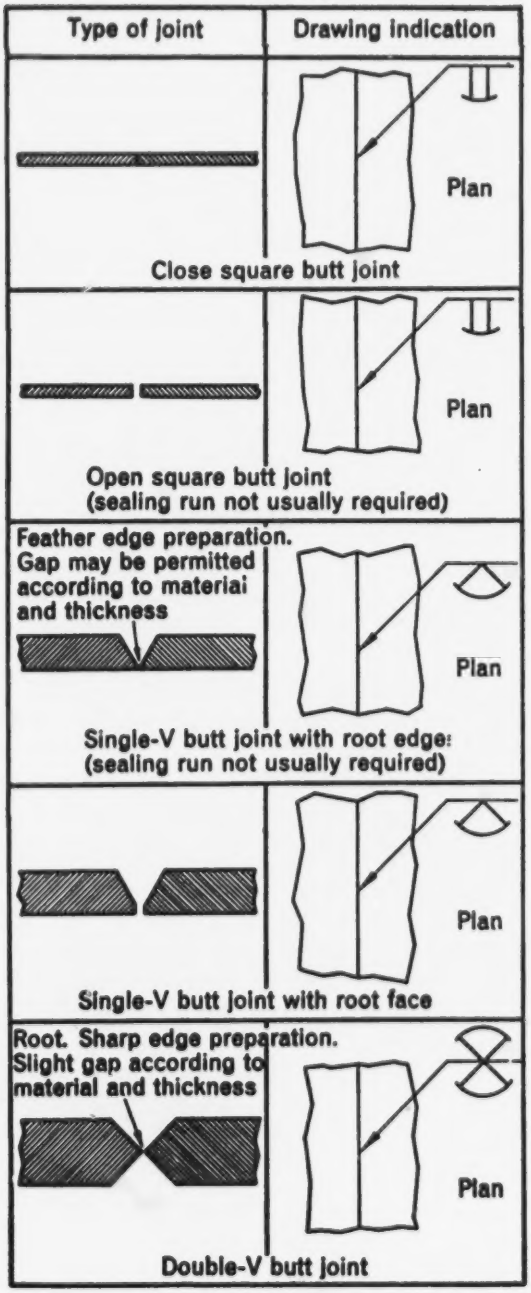
1. A symbol for the type of welded joint.

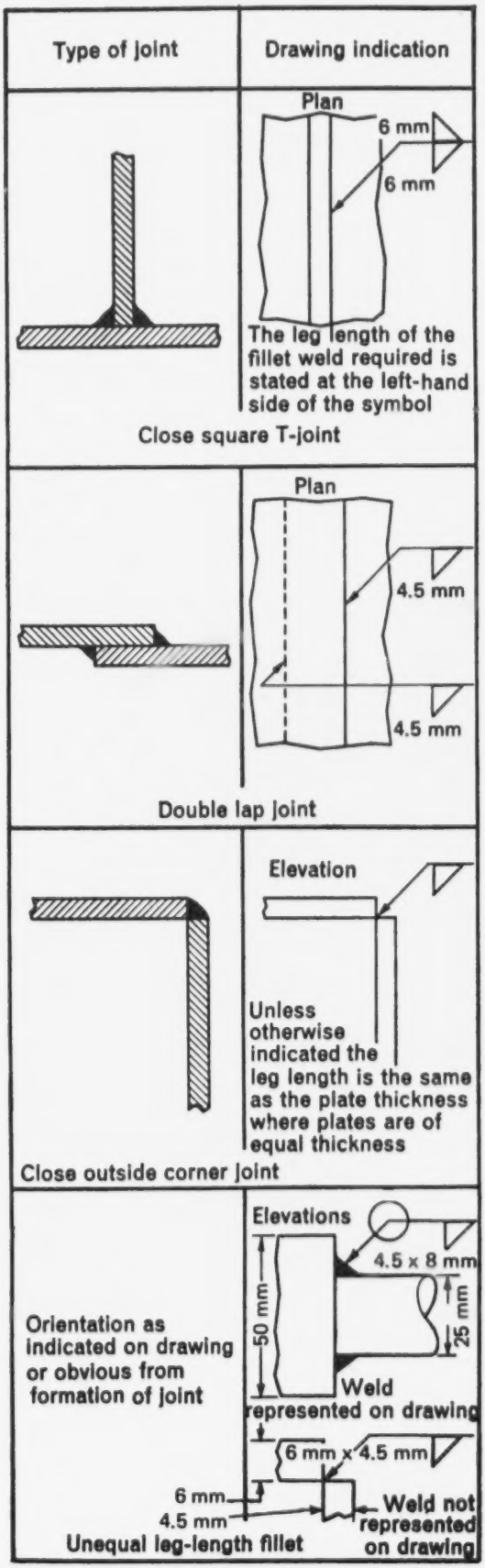
2. An arrow and reference line to indicate the position of the weld.

3. The addition of weld details where necessary.

4. Symbols for supplementary instructions.

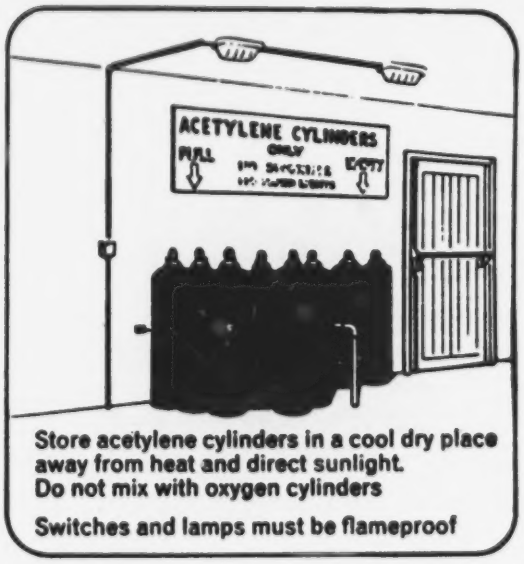
Gas welding




Type of joint
Drawing indication
Plan
6 mm
6 mm
The leg length of the fillet weld required is stated at the left-hand side of the symbol
Close square T-joint
Plan
4.5 mm
4.5 mm
Double lap joint
Elevation
Unless otherwise indicated the leg length is the same as the plate thickness where plates are of equal thickness
Close outside corner joint
Elevations
4.5 x 8 mm
50 mm
25 mm
Orientation as indicated on drawing or obvious from formation of joint
Weld represented on drawing
6 mm x 4.5 mm
6 mm
4.5 mm
Weld not represented on drawing
Unequal leg-length fillet

Handle cylinders carefully!

Make sure cylinders are secure



Store acetylene cylinders in a cool dry place away from heat and direct sunlight.
Do not mix with oxygen cylinders

Switches and lamps must be flameproof

Never allow oil or grease to be on cylinder valves or cylinder fittings. **Oxygen reacts explosively with oil or grease.**

General Safety Precautions and Fire Prevention Measures

Gas Cylinders

Gas cylinders are recognized by a colour code.

1. Oxygen: Black 2. Acetylene: Maroon

Store oxygen and fuel gas cylinders apart.

Handle cylinders carefully. Take care that they are not dropped or allowed to fall from a height.

Cylinders should be used in an upright position and fastened to prevent them falling or being knocked over.

Accidental 'arcing' on cylinders may create a serious hazard

Do not allow any flame near cylinder walls.
Do not allow any electric arc welding to be undertaken in the immediate vicinity.

If fire breaks out try to remove all gas cylinders to a safe place.

Fuel Gas Cylinders

Close cylinder valve when not in use.

If gas leaks when valve is closed:

1. Move the cylinder into the open, and away from electric motors and sources of sparks or heat.

2. Forbid smoking or naked light.

3. Ensure suppliers are advised immediately.

Acetylene and other fuel gases are highly flammable and form explosive mixtures with air and oxygen. **Fuel gas leaks are a source of fire risk.**

Oxygen Cylinders

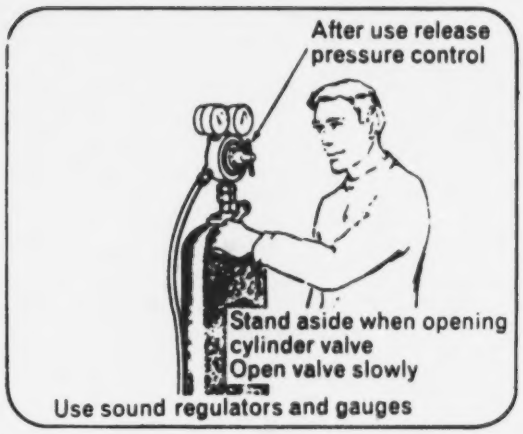
1. **Do not** inhale oxygen from the cylinder.

2. **Do not** use it as a method of ventilation.

3. **Do not** allow it to leak.

4. **Do not** use oxygen as a substitute for compressed air.

In an oxygen-enriched atmosphere, clothing and any combustible material can be ignited easily by a spark and will burn fiercely.


After use release pressure control
Stand aside when opening cylinder valve
Open valve slowly
Use sound regulators and gauges

Regulators

Do not use regulators with broken gauges.
Do not stand in front of gauge faces when opening cylinder valve.

Select the correct regulator for the gas being used.

Do not use:
(a) Low Pressure regulator on Dissolved Acetylene cylinders.

(b) Dissolved Acetylene regulator on hydrogen cylinders.

(c) Compressed air regulator on oxygen cylinder.

Hoses

Use only pressure type rubber canvas hose in good condition and fitted with the correct type of connections.

Do not allow hoses to 'kink' or tangle and thus obstruct the gas flow.

Keep hoses clear of abrasive surfaces, sharp edges, and hot metal.

Do not allow traffic to pass over them.

Do not pass oxygen through hose previously used with compressed air.
Use the correct fittings to join lengths of hose or when repairing damaged hose.
Never use copper pipe on acetylene hose connections.

Working Area

Welding and cutting should be performed in areas free from fire risk.

Wooden floors should be covered with non-combustible material and kept clean and free from litter within 10 m of welding and cutting operations.

Lighting Blowpipes

Spark lighters are recommended. Do not use methods involving fire risk.

Ventilation

Ensure there is thorough natural ventilation during welding and cutting operations.
Do not allow fuel gases to leak into the atmosphere.

Cutting

Dross must be caught in a metal receptacle.

Ensure material being cut is adequately supported and that the discard cannot fall and cause personal injury.

Ensure suitable fire extinguishing equipment, including buckets of dry sand, is readily available and maintained in good condition.

Flashbacks

If 'backfire' is arrested at the blowpipe mixer or injector no damage will occur, provided the blowpipe valves are closed promptly.

Outward signs of a severe flashback include:
A squealing or hissing noise; heavy black smoke; sparks coming out of nozzle; blowpipe handle overheating.

In such cases:
1. Turn off cylinder valves.

2. Detach regulators and equipment from cylinders.

3. Check hoses and blow-pipe for damage before re-use.

When gas from the cylinder catches fire at the valve or regulator because of leakage at the connection:

1. Close the cylinder valve, wearing asbestos gauntlet gloves.

2. Make the leaky joint gas-tight before further use.

If cylinder becomes overheated or if fire prevents immediate closing of valve:
1. Extinguish flame by using a Carbon Dioxide fire extinguisher or by smothering with an asbestos blanket.

2. Remove the cylinder to open space; forbid smoking or naked lights in the vicinity.

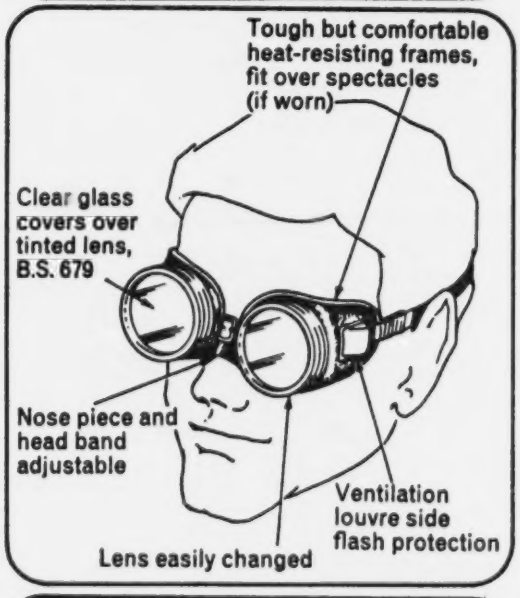
3. Cool cylinder by spraying it with water.

4. Advise the suppliers immediately.

Fire Precaution

Keep fuel gas cylinder valve key to hand so that gas supply can be turned off immediately.

Asbestos gauntlet gloves should be available at all times.


Tough but comfortable heat-resisting frames, fit over spectacles (if worn)
Clear glass covers over tinted lens, B.S. 679
Nose piece and head band adjustable
Ventilation louvre side flash protection
Lens easily changed

Protective Equipment

The eyes must be protected from heat and glare, and from particles of hot metal or scale.

Goggles

These should be fitted with an approved lens.

Use:

Shade 4 G W for light work
Shade 6 G W for heavier work

Lens supplied for gas welding and cutting operations must not be used for arc welding and cutting.

Protective Clothing

Normal Dress

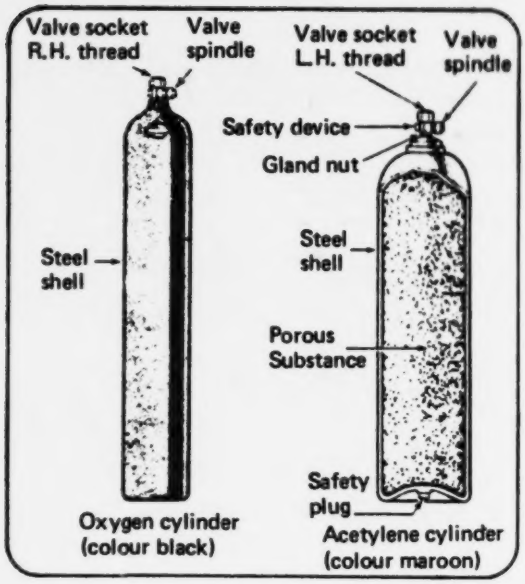
The outer clothing should be free from oil, grease or flammable substances. Cuffs on overalls, and turn-ups on trousers, are possible lodging places for sparks or globules of hot metal.

Special Protection

The protective clothing worn depends upon the nature of the work. Safety boots and asbestos spats should be worn when doing cutting work.

Leather gloves should be worn for all cutting operations involving the handling of hot metal.

Gauntlet gloves and leather apron should be worn when working on vertical and overhead material.



Welding Equipment

Oxygen Cylinders

The steel cylinders are painted black; usual sizes are 3.39 m^3 (120ft^3), 6.78 m^3 (240ft^3) and 8.49m^3 (300ft^3).

The valve outlet has a right-hand screw thread.

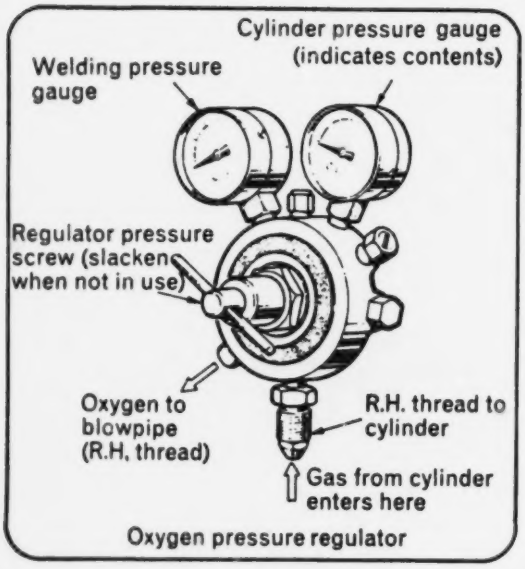
Mild steel cylinders are charged to pressure of 136.5 bars (1980 lb/in^2); alloy steel cylinders to 172.5 bars (2500 lb/in^2).

Acetylene Cylinders

The steel cylinders are painted maroon. They contain porous substances with acetone to act as solvent for the gas hence 'dissolved acetylene'. The usual sizes are 3.39m^3 (120ft^3) and 5.66m^3 (200ft^3).

The valve outlet has a left-hand screw thread.

Cylinders are charged to pressure of 15.5 bars (225 lb/in^2).


Cylinder pressure gauge (indicates contents)
Welding pressure gauge
Regulator pressure screw (slacken when not in use)
Oxygen to blowpipe (R.H. thread)
R.H. thread to cylinder
Gas from cylinder enters here
Oxygen pressure regulator

Manifolds

Two or more cylinders may be manifolded together.

Regulators

Pressure regulators are required to reduce cylinder gas pressure to required working pressure.

Regulators for oxygen cylinders have right-hand screw thread.

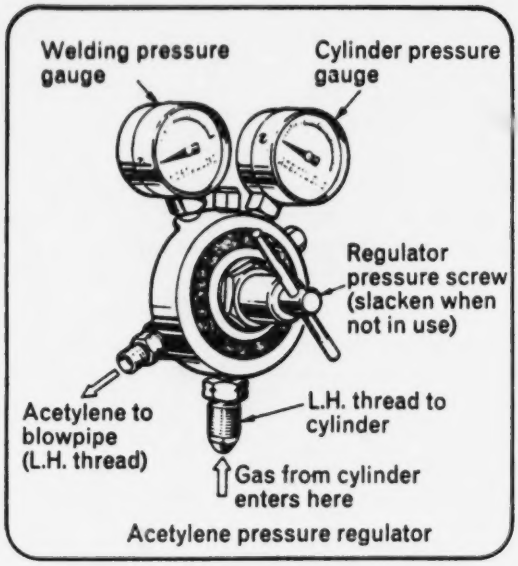
Regulators for acetylene cylinders have left-hand screw thread.

Pressure Gauges

For oxygen these should read up to 30 lb/in^2 (2.08 bars) for outlet pressure.

For acetylene these should read up to 15 lb/in^2 (1.04 bars) for outlet pressures.

140


Welding pressure gauge
Cylinder pressure gauge
Regulator pressure screw (slacken when not in use)
Acetylene to blowpipe (L.H. thread)
L.H. thread to cylinder
Gas from cylinder enters here
Acetylene pressure regulator

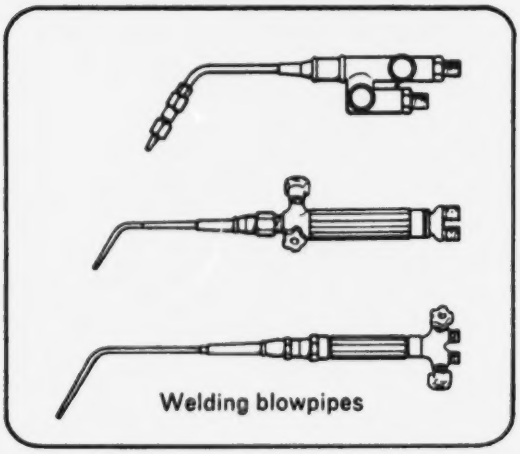
Contents indicators

Pressure gauges can be used to indicate the amount of oxygen in the cylinder. Gauges used for this purpose should have a dial reading of not less than 4,000 lb/in^2 (275 bars).

A 'pop-up' device pre-set to indicate the cylinder contents may be used on oxygen cylinders.

Pressure gauges having a dial reading of not less than 600 lb/in^2 (41 bars) can be used to indicate pressure in an acetylene cylinder.

Pressure gauges cannot be used to indicate the contents of dissolved acetylene cylinders. The weight of the cylinder compared to its pre-charge weight is the only guide to content.


Welding blowpipes

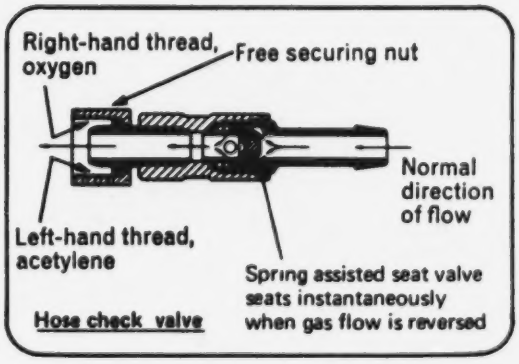
Nozzles

Nozzles for welding blowpipes may be gooseneck extensions fitting into the mixer portion of the blowpipe, or tips to screw on to the head of the blowpipe.

Size numbers for high-pressure nozzles usually indicate the approximate consumption of each gas in ft^3/hr. (non-metric), when using a neutral flame.

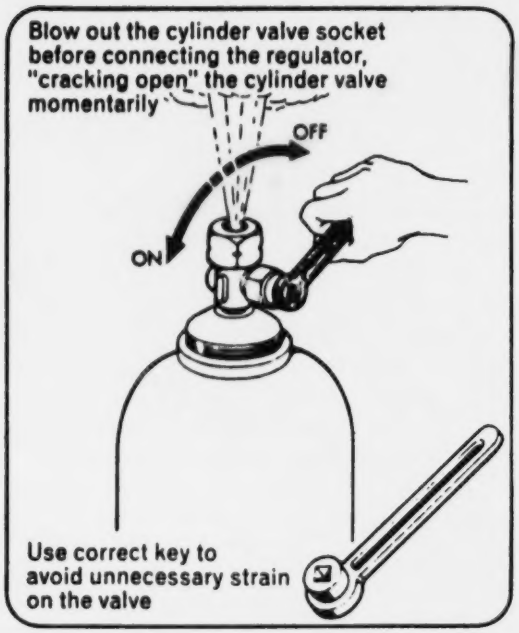
Hoses

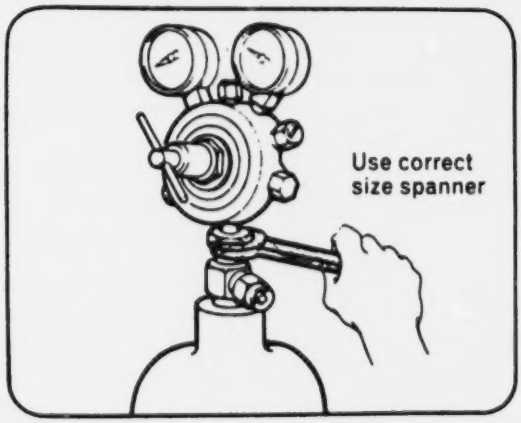
Hoses for oxygen are black or blue. Right hand threaded connections. All further references to Black hoses should be taken to mean Black or Blue.

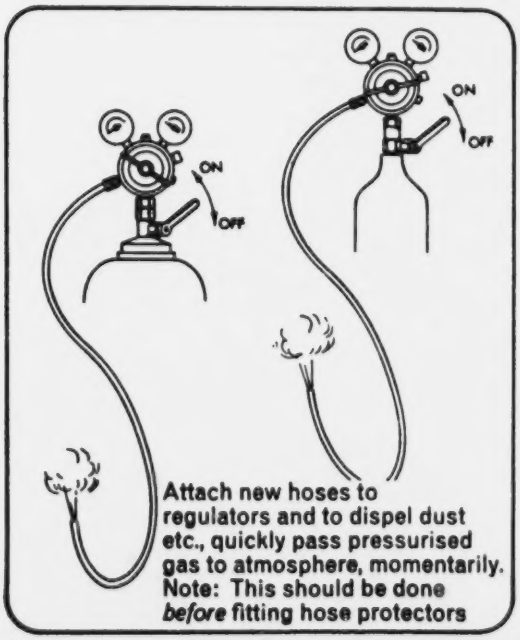

Right-hand thread, oxygen
Free securing nut
Normal direction of flow
Left-hand thread, acetylene
Spring assisted seat valve seats instantaneously when gas flow is reversed
Hose check valve

Hose Protecting Devices

These should be fitted at the blowpipe end of the hoses. They eliminate conditions of flashback and backfire by preventing gas in a line feeding into the other line, which is at lower pressure.


Blow out the cylinder valve socket before connecting the regulator, "cracking open" the cylinder valve momentarily
OFF
ON
Use correct key to avoid unnecessary strain on the valve




ON
OFF
ON
OFF
Attach new hoses to regulators and to dispel dust etc., quickly pass pressurised gas to atmosphere, momentarily. Note: This should be done *before* fitting hose protectors

Safety

Do not use any oil, grease or oil-based substance to aid the assembly of equipment. IT MAY CAUSE AN EXPLOSION.

Connecting Regulators

Before screwing the regulator into the outlet-valve socket make sure that the socket is clean, dry, and free from dust.

Screw regulator into valve socket until gently home, then a sharp blow with the hand on the spanner shaft will ensure a gas-tight seating.

Slacken regulator pressure-control screw to relieve pressure on the regulator diaphragm.

Connecting Hoses

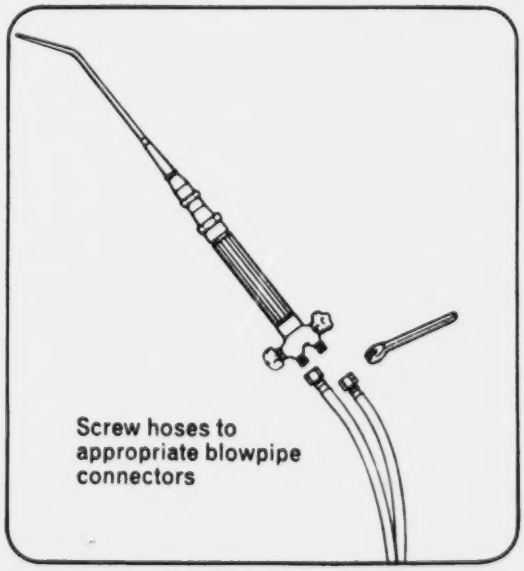
Attach hoses to the regulators making sure that an anti-flashback device is fitted at the blowpipe end of the hose. Tighten all nuts, using only the correct size spanners.

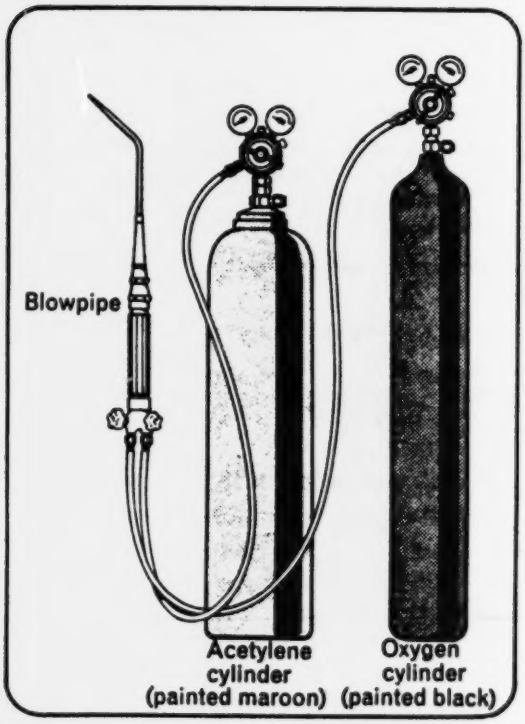
Connecting Blowpipe

Using correct size spanner, screw hose connectors on to the blowpipe after fitting hose protectors.

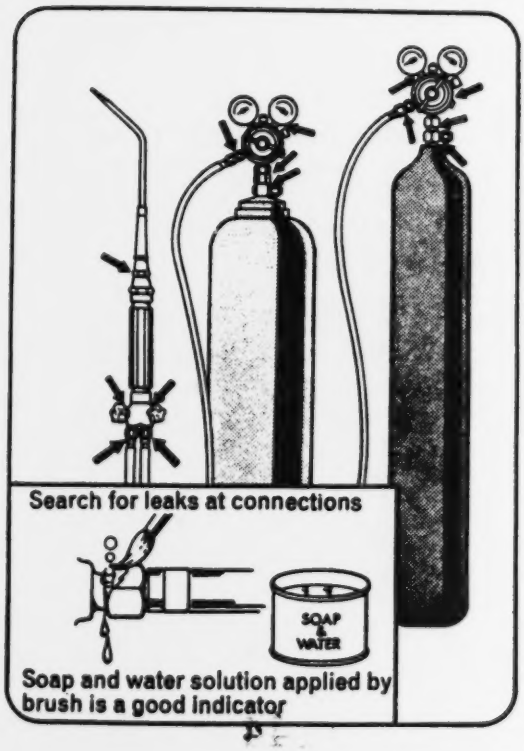
Fit welding nozzle to blowpipe; do not strain by over-tightening.

Nozzle size and gas pressures appropriate to the size are quoted by equipment manufacturers to suit thickness and type of material being welded.





DO NOT INVESTIGATE FOR GAS LEAKS WITH A NAKED FLAME



Pressurizing System

1. Close the blowpipe valves.

2. Turn on the gases.

3. Dealing with one gas at a time:
(a) Open the blowpipe valve.
(b) Set the working pressure by adjusting the regulator control.
(c) ALLOW GAS TO FLOW SO THAT THE HOSE IS PURGED OF ANY OTHER GAS.
(d) Close the blowpipe valve.

4. The system is then pressurized and purged.

Leak Testing

At this stage carefully check the system for leaks using soap solution or 5% Teepol in water solution.

Apply at all connections using a small soft hairbrush or fitch.

Escaping gases can be detected by sound and feel (or smell in the case of acetylene).

When a leak is found rectify immediately. Even small amounts of acetylene escaping into a confined space can cause a serious explosion.

Closing Down Procedure

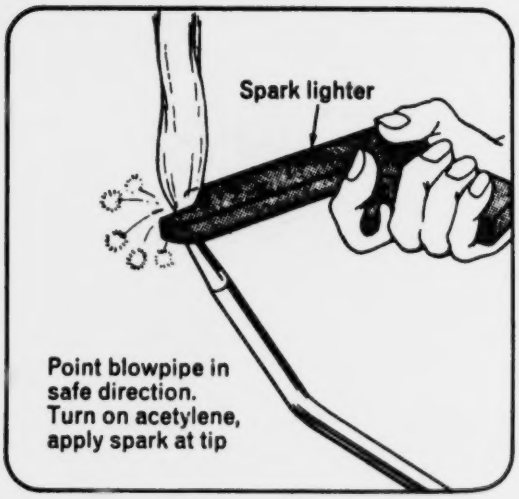
At the end of the work period, or when there is a long interruption, close down the system:

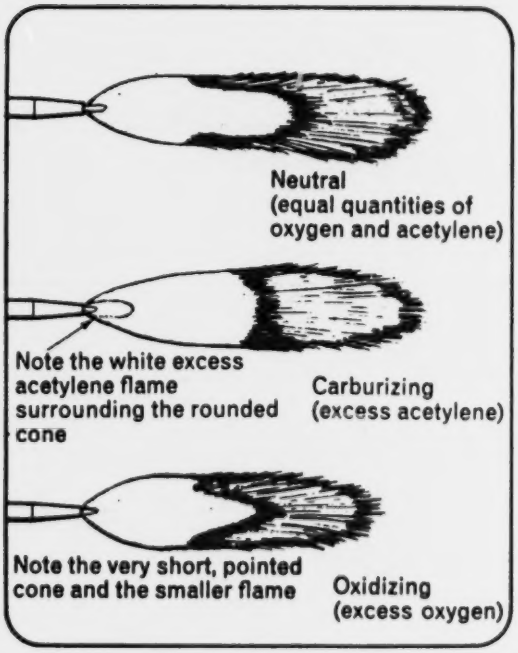
1. Turn off the blowpipe control valves, the acetylene valve first and then the oxygen valve.

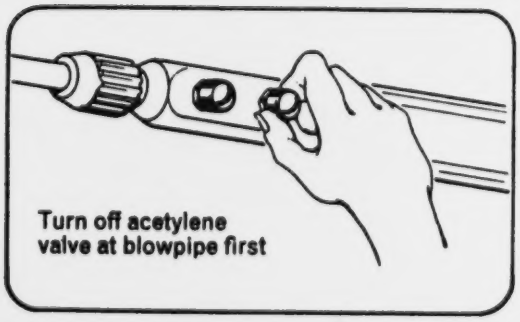
2. Close the cylinder valves.

3. Release the pressure in the hoses by first opening the oxygen valve on the blowpipe and closing it.

4. Release the pressure on the regulator diaphragms by turning the pressure-regulating screw to the minimum pressure position.




Neutral
(equal quantities of oxygen and acetylene)
Note the white excess acetylene flame surrounding the rounded cone
Carburizing
(excess acetylene)
Note the very short, pointed cone and the smaller flame
Oxidizing
(excess oxygen)



The welding Flame

The essential requirement for oxy-acetylene welding is a hot, controlled flame easily manipulated, to heat or melt metal without altering the chemical composition of the metal.

Lighting and Adjusting the Blowpipe Flame

1. Close all valves on the blowpipe.

2. Open cylinder valves very slowly by *one turn only* of the spindle.

3. Set the regulators to the correct working pressures.

4. Open the acetylene control valve on the blowpipe about three-quarters of a turn.

5. Wait a few seconds while the acetylene flushes the system (ensure that the blowpipe is pointed in a safe direction). This purges the blowpipe from the mixer forward and prevents backfires on lighting up.

6. Using a spark lighter, light the acetylene.

7. Reduce or increase the gas supply, by operating the blowpipe valve, until flame just ceases to smoke.

8. Open the oxygen control valve on the blowpipe until the white inner cone in the flame is sharply defined with the merest trace of 'feather' or acetylene haze at the tip.

This is the neutral flame used for all welding of mild steel.

9. To extinguish the flame, close the acetylene valve and then the oxygen valve on the blowpipe. Alternatively, hang lit blowpipe on gas economizer valve-control lever.

Operating the equipment
The following general instructions, which are not repeated later in the text, apply to oxy-acetylene welding.

> **Safety**
> Do not remove the cylinder key from the acetylene cylinder, it may be needed urgently for fire prevention purposes. Keep asbestos gloves handy.

Always

1. Comply with the prescribed safety precautions and fire-prevention procedure.
2. Check that hoses are not 'kinked' or otherwise obstructed.
3. Check that correct size nozzle is fitted to blowpipe.
4. Check that cylinder valves are open.
5. Check that regulators are set to correct working pressures.
6. Use effective protective equipment and any necessary protective clothing.
7. If gas economizer is used, check that pilot light is lit.
8. Point the blowpipe in a safe direction when lighting.
9. Handle the lit blowpipe with due caution and take care that the flame does not impinge on gas-cylinder walls.
10. Concentrate on watching the welding operation.
11. Hold the blowpipe with just sufficient grip at the point of balance to give full control.
12. Extinguish blowpipe flame when not in use or when moving location, and follow closing-down procedure when necessary.

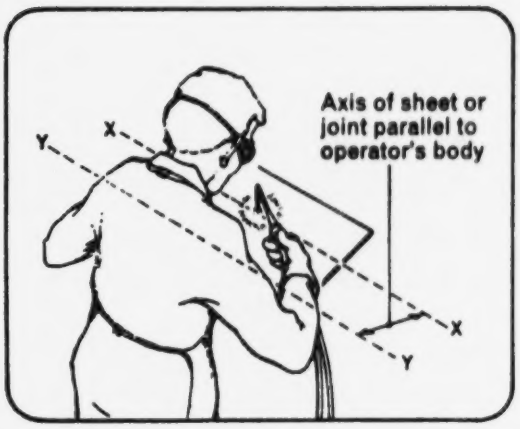
Leftward Welding
In leftward welding the flame is directed towards the unwelded part, and the filler rod when used is directed towards the welded part of the joint.

With the blowpipe held in the right hand, welding proceeds from right to left; with the blowpipe held in the left hand, welding proceeds from left to right. In vertical welding the movement is upwards.

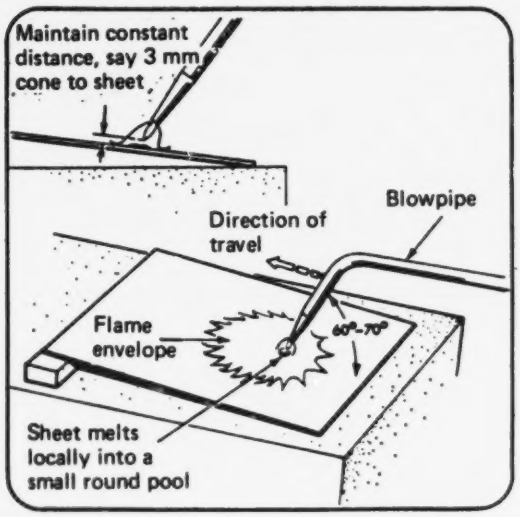
This technique is used for welding steel in thicknesses less than 5 mm. In the vertical position it is also used for the welding of plates up to 15 mm thick where two people weld each side simultaneously. The technique is infrequently used for overhead and all-position welding.

Fusion without Filler Metal

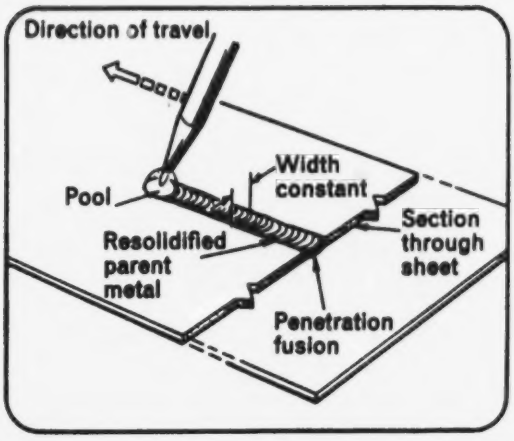
Material	One piece of mild steel 1.5 mm thick. Min. size 10 cm x 20 cm.
Preparation	clean surface
Assembly	right-hand short edge of sheet resting on bench, left raised about 15 mm.
Nozzle size	2 (57 litres/hr. each gas)
Regulators	each 0.14 bars (2 lb/in^2)



1. Set flame to neutral, and with goggles in position, lower blowpipe until the end of the inner cone is about 3 mm above sheet surface near right-hand edge.


Maintain constant distance, say 3 mm cone to sheet
Direction of travel
Blowpipe
Flame envelope
60°-70°
Sheet melts locally into a small round pool

2. Adjust angle of nozzle to $60^{o} - 70^{o}$ to sheet, positioning in direction of travel.



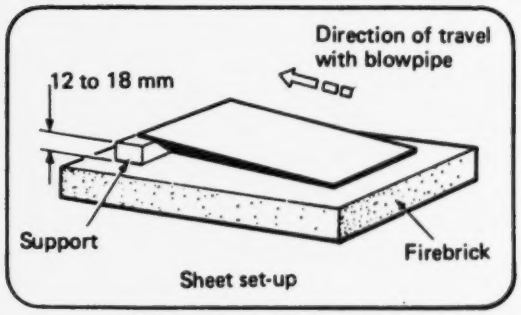
3. As soon as local fusion (to form a small round pool of molten metal) is achieved, move the blowpipe in leftwards direction.

4. Synchronize rate of travel with the progressive formation of the molten pool and avoid excess concentration of heat.

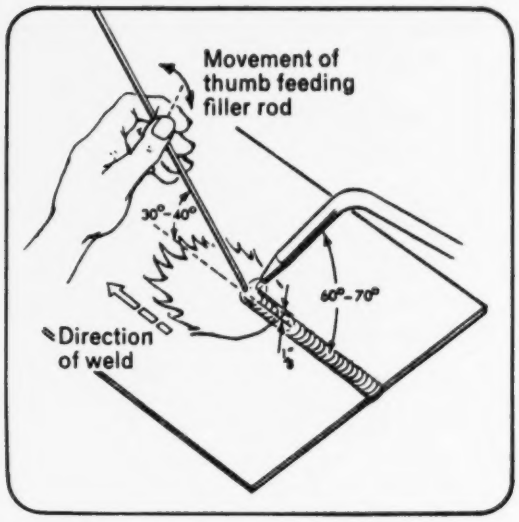
5. If speed of travel is correct the fused and solidified metal will be uniform in width.

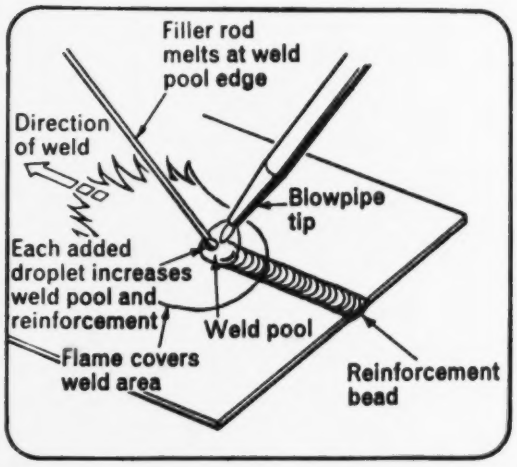
Depositing Straight Runs

Material	One piece of mild steel 1.5 mm thick. Min. size 10 cm x 20 cm.
Preparation	clean surface
Assembly	support in slightly inclined position
Nozzle size	2 (57 litres/hr. each gas)
Regulators	each 0.14 bars (2 lb/in^2)
Filler rod	1.6 mm BS 1453/A1



Sheet set-up




Filler rod melts at weld pool edge
Direction of weld
Blowpipe tip
Each added droplet increases weld pool and reinforcement
Weld pool
Flame covers weld area
Reinforcement bead

1. With the blowpipe nozzle held at an angle of 60° – 70°, establish small pool of molten metal at right-hand edge of sheet.

2. Hold filler rod in left hand, pointing at the front edge of molten pool and at an angle of 30° – 40° to sheet surface.

3. Allow the flame to melt a droplet of metal from the end of the filler rod.

4. Start the progressive leftwards movement of blowpipe and filler rod.

5. Keep the end of the filler rod within the flame envelope but not in the hot portion near the cone.

6. Continue addition of molten filler metal by moving the end of the filler rod repeatedly to the front edge of the molten pool and the hotter portion of the flame.

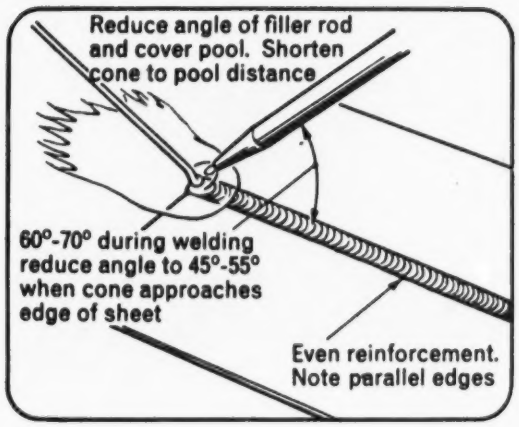
7. Rate of travel leftwards should be co-ordinated with melting of filler rod to control size of bead and extent of penetration.

8. When near the left-hand edge of the sheet slowly withdraw the flame.

Stopping and Re-starting

An incorrectly finished weld or an uneven join-up in a weld run may be a source of weakness. Care must be taken to build up craters at the ends of runs and to make smooth join-ups.

The following techniques should be used in all future oxy-acetylene welding procedures unless otherwise stipulated.


Reduce angle of filler rod and cover pool. Shorten cone to pool distance
60°-70° during welding reduce angle to 45°-55° when cone approaches edge of sheet
Even reinforcement. Note parallel edges

Building Up Crater

1. Use the welding conditions as page 38.

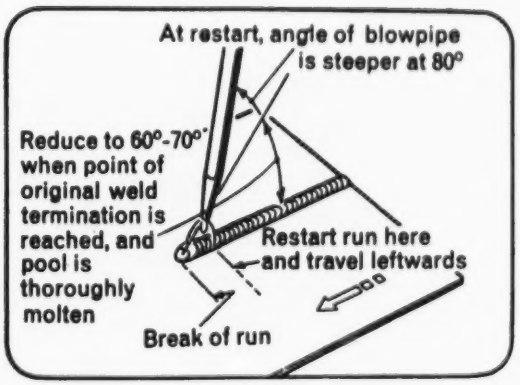
2. As the weld pool nears the left-hand edge slightly reduce the angle of the blowpipe nozzle to reduce heat concentration.

3. At the same time slightly reduce the angle of the filler rod.

4. At the edge of the sheet, add a little filler metal and advance the tip of the white cone nearer to the weld pool.

5. Remove the flame, gradually covering the weld pool with the end of the filler rod to protect the solidifying weld metal.

6. Remove filler-rod end from weld zone before solidification occurs.

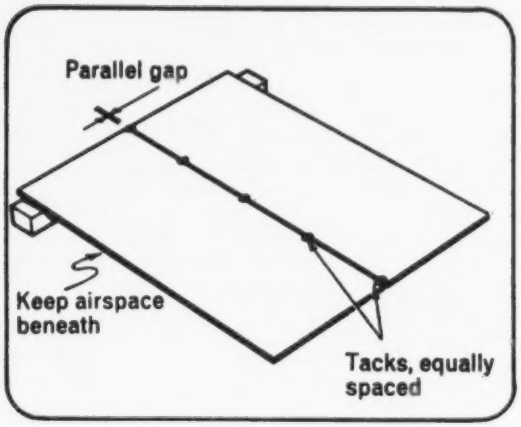

At restart, angle of blowpipe is steeper at 80°
Reduce to 60°-70° when point of original weld termination is reached, and pool is thoroughly molten
Restart run here and travel leftwards
Break of run

Re-starting

1. Using welding conditions as page 38 interrupt the deposition after 50 mm run length, removing flame slowly.

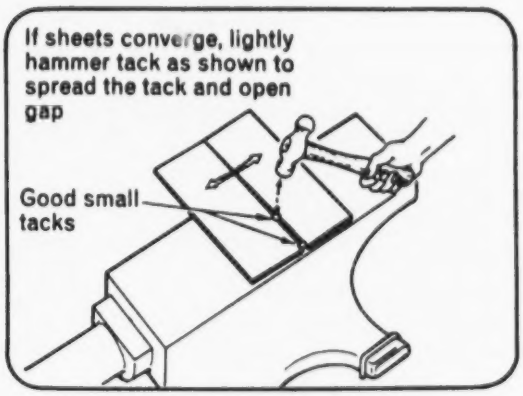
2. To re-start, apply the blowpipe nozzle at 80° angle with the cone pointing on the last 3 mm of weld bead deposited.

3. When the end of the weld bead has re-melted add filler metal to the molten pool and proceed with the deposition.



Tack Welds

Tack welding is important particularly for the maintenance of gap and alignment of parts. Tack welds on sheet metal should be short in length but must be sound and sufficient in number to prevent movement of the parts being welded. The distance between tacks should be about 40 mm for sheet metal up to 1.5 mm and about 50 mm for sheet metal between 1.5 mm and 5 mm thickness. These distances may be doubled for fillet-welded T joints.



Tack Welding Procedure

1. Tack welds should be on the side to be welded and in the line of the joint.

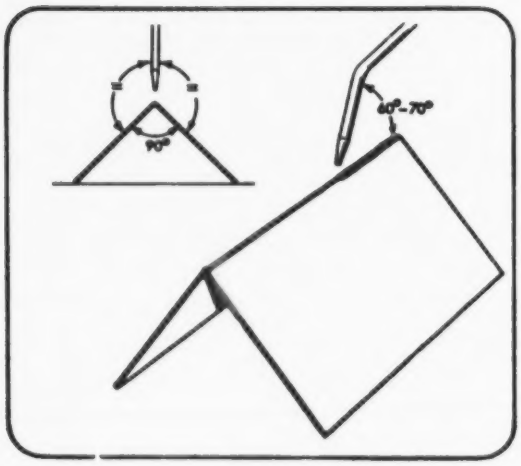
2. Heat small triangular area with blowpipe to melt the parent metal where the tack weld is required.

3. Add filler metal to molten pool to make a small but sound weld and then remove flame.

4. Repeat until all tack welds are made, making sure that the gap is kept uniform and of the correct size (where a gap is required).

Flat Position

Close Outside Corner Joint without Filler



Material	Two pieces of mild steel 1.25 mm thick. Min. sizes 10 cm x 15 cm.
Preparation	square edge
Assembly	tack weld with five tacks to give included angle of 90^{o} without gap and no filler metal (see note)
Nozzle Size	2 (57 litres/hr. each gas)
Regulators	each 0.14 bars (2 lb/in^2)

1. Heat the sheet corners at the right-hand end of the joint until the tack weld fuses.

2. Immediately progress leftwards along the joint.

3. The nozzle of the blowpipe should be at an angle of $60^{o} - 70^{o}$ and directed to secure fusion of both edges of the sheets.

4. Keep the tip of the white cone about 3 mm above the weld pool.

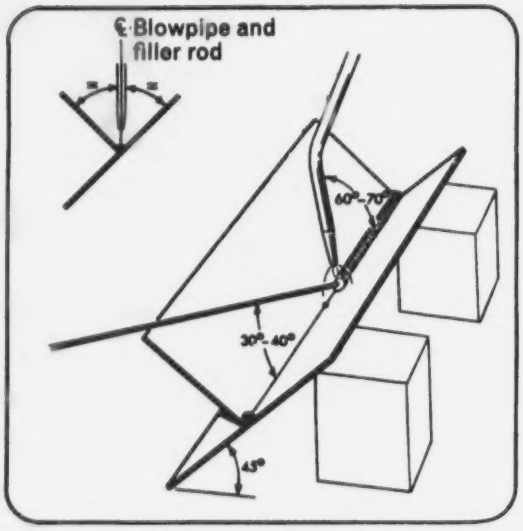
5. Adjust the rate of leftwards travel to secure fusion without burning through the sheets.

Note: A piece of filler rod may be used to control fusion where necessary.

Visual examination

If the speed of travel has been correct, complete fusion of the fusion faces will be achieved. The underside of the joint will show a descaling line on each sheet near the root of the joint or a slight penetration bead.
If 'holding' of the sheet (burn through) has occurred this will be the result of excess concentration of heat locally and indicates that the speed of leftwards travel has been too slow.

T Joint (Gravity Fillet)



Material	Two pieces of mild steel 1.5 mm thick. Min. sizes 10 cm x 15 cm.
Preparation	square edge
Assembly	tack weld with three tacks so that the sheets form an inverted T. without gap between the sheets. Support the lower sheet so that it is tilted at 45° transversely
Nozzle size	3 (86 litres/hr. each gas)
Regulators	each 0.14 bars (2 lb/in^2)
Filler	1.5 mm BS 1453/A1

1. Commence the weld at the right-hand end of the joint.

2. The blowpipe nozzle angle should be 60° – 70° and the filler rod held at an angle of 30° – 40°.

3. When tack weld fuses, immediately add filler metal to establish weld pool and commence the leftwards progression.

4. Do not weave blowpipe but add filler metal at front edge of the weld pool.

5. Adjust the rate of travel to secure even penetration into both sheets and to produce a fillet weld of equal leg lengths.

Visual Examination

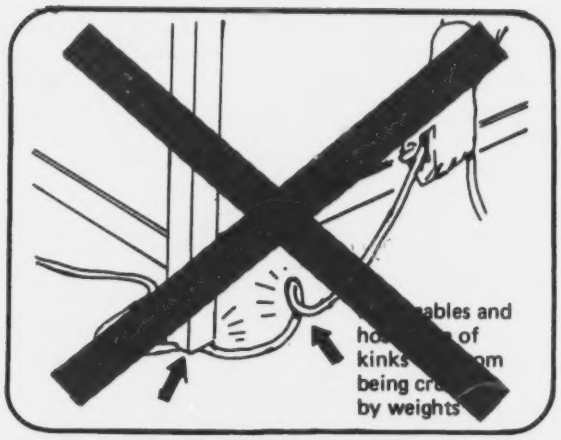
In a satisfactory weld the profile will be uniform and slightly concave. There should be freedom from undercut at the toes of the weld. The leg lengths should be equal and between 4 mm and 5 mm.

General Safety Precautions and Fire Prevention

Power Sources
Make sure they are correctly connected to the appropriate mains supply and adequately earthed. Seek the advice and assistance of competent persons.

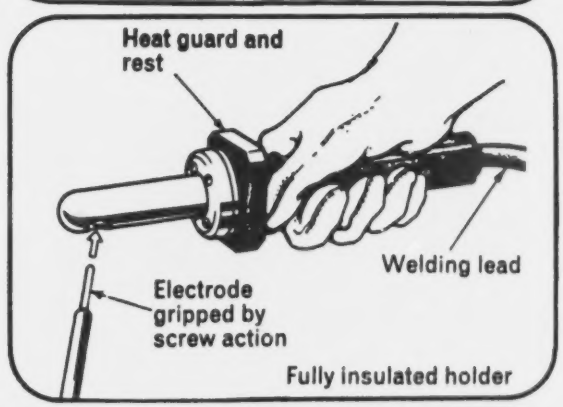
Switch off mains supply to power source when work is finished.

Cables
Keep cables clear of ladders, gangways, and doors.



Do not allow traffic to pass over cables.

Disconnect from power source before joining any cables. Never use damaged cables.

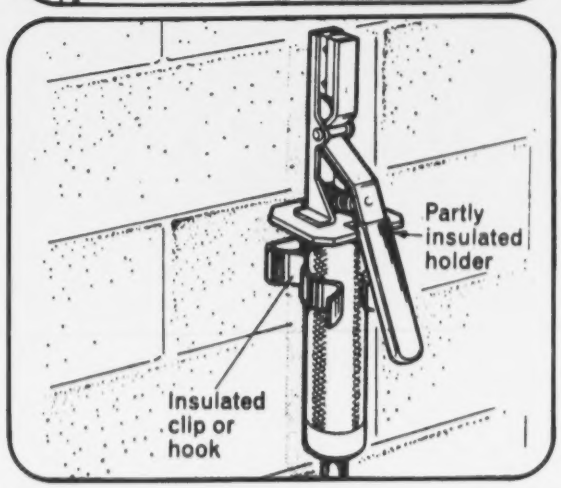


Electrode Holders
Use a fully insulated holder when

1. Welding in a confined space.

2. There is difficulty of access to the weld because of the proximity of metal parts.

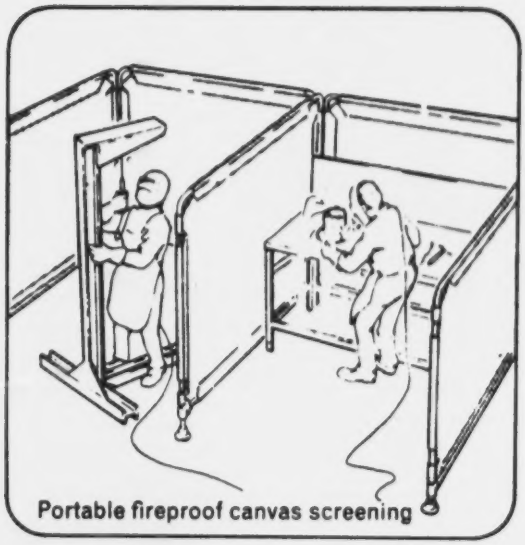
3. Welding a steel which may be hardened by accidental 'arcing'.



When using a partly insulated holder avoid contact with metal parts causing 'stray flashes'.

When the holder (torch or gun) is not being used place it securely on an insulated hook.

Do not dip hot electrode holders in water.



Portable fireproof canvas screening

Working Area

Keep the working area tidy and free from flammable material.

When cutting material make sure that the detached portion cannot fall and cause personal injury.

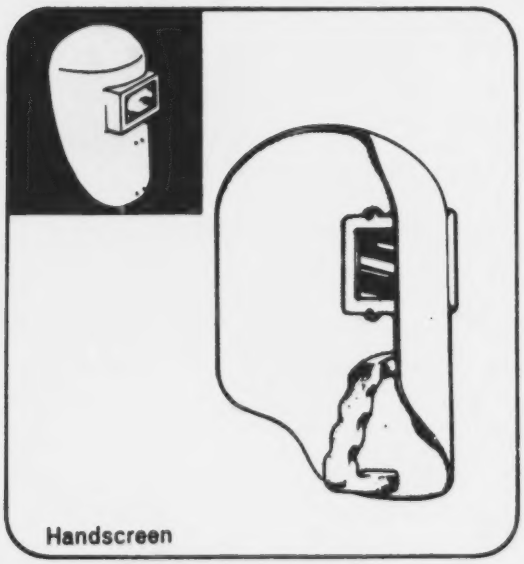
Beware of the danger from beads of hot metal when arc cutting.

> Ensure suitable fire extinguishing equipment is readily available and maintained in good condition.

Protective Equipment

Avoid exposure of yourself and others to the heat and light radiations of the welding arc.

Note: Radiations include *invisible* ultra-violet and infra-red rays.



Handscreen

Screening — General

Screen arc-welding and cutting operations so that persons who work in the vicinity are protected from 'flashes'.

> **Safety**
> Exposure of the eyes to arc emissions causes severe irritation and watering of the eyes. This symptom occurs some 4 to 8 hours after exposure.

Adjustable helmet

Screening — Personal

For most operations a hand held screen made of lightweight, insulating, and non reflecting material can be used. It must have an approved 'filter glass'.

Goggles alone do not give adequate protection for arc-welding and cutting operations.

Make sure that the screen is of a size and shape to shield the face, throat, wrist and hand.

Where it is necessary to protect the head or to have both hands free a helmet type screen fitted with an approved filter should be used.

Protective Clothing

Normal Dress

Outer clothing should be free from oil, grease or flammable substances. Protect the forearms from exposure to arc rays; do not roll up sleeves.

Cuffs on overalls, turn-ups on trousers, exposed long hair and low-cut shoes are likely lodging places for sparks or globules of hot metal and slag.

Special Protection

Protect the front of the body from about the throat to the knees with suitable leather cape and apron. If only an apron is worn this must provide full protection.

Wear suitable leather gloves to protect the wrists and hands.

Arc Eye

Exposure to welding arcs can cause burns to the skin similar to sunburn and also severe irritation to the eye. This condition is known as "Arc Eye". Symptoms become apparent 4 to 8 hours after exposure and include watering eyes, headache and partial loss of vision.

When symptoms occur:

1. Use an eye bath to wash the eyes with an approved eye lotion.

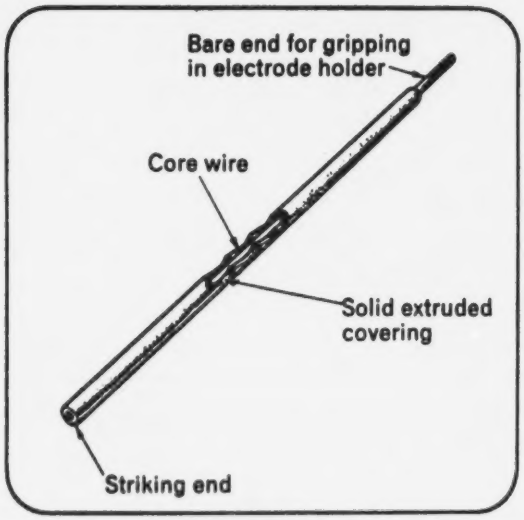
2. Repeat at about four-hourly intervals.

3. In the meantime cold compresses, made by soaking cotton wool in cold water (which has been boiled previously), may be applied.

4. If going into bright light, dark glasses should be worn.

5. Report to the first-aid room as soon as possible.

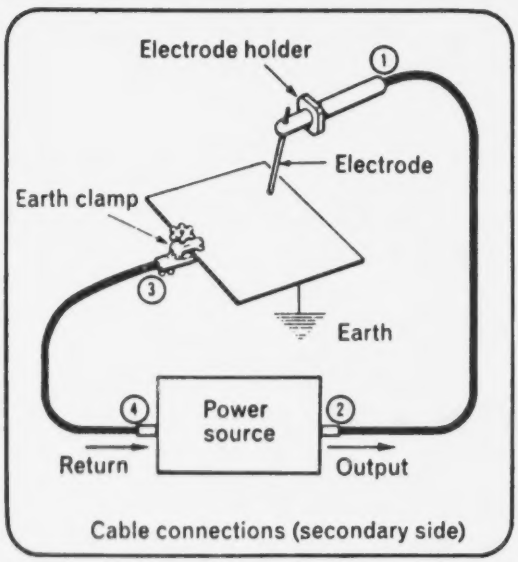
If recovery from 'Arc Eye' is not complete in 36 to 48 hours, medical advice must be sought.



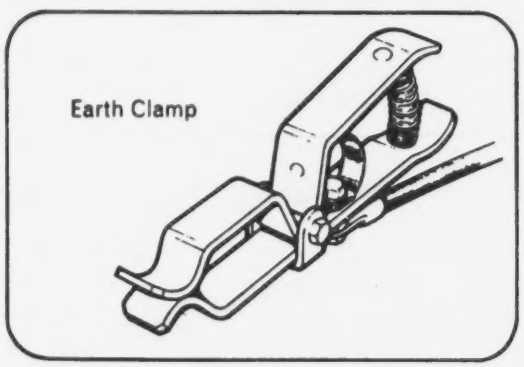
Important

Electrodes should be stored and used in a dry condition.

Carefully segregate different types and sizes of electrodes.



Cable connections (secondary side)



Electrodes

Construction of Electrode

The filler metal is provided by the melting of an electrode. The grip end, which is inserted in the electrode holder, is bare of covering for a distance of approximately 3 cm.

The other end, known as the striking end, is sometimes pointed to ensure good electrical contact when striking the arc.

Purposes of the Electrode covering are:

1. To give stability to the arc.
2. To provide good arc transfer conditions.
3. To control the reactions occurring during welding.
4. To protect the molten metal during transfer.
5. To provide good welding characteristics.
6. To provide a suitable slag protection for the cooling weld.
7. To ensure that the deposited metal has satisfactory chemical, physical, and mechanical properties.

Installation of Equipment

The initial installation and connection of the power source to the appropriate mains supply should be carried out by a competent person. Ensure that the equipment is adequately earthed.

Connections for Secondary Side

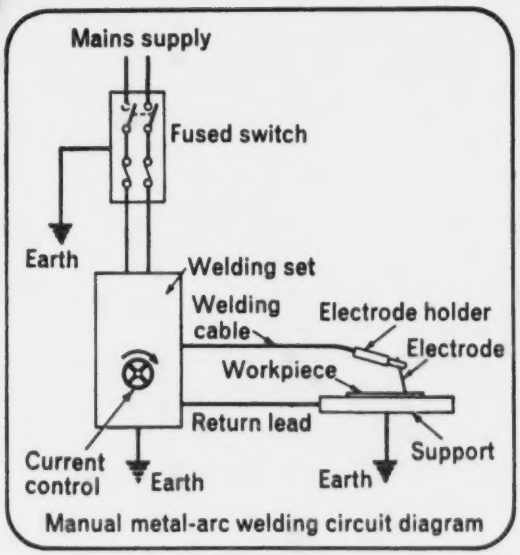
Use secondary cables of a suitable size for the maximum welding current.

1. Connect one end of the welding lead to the electrode holder.

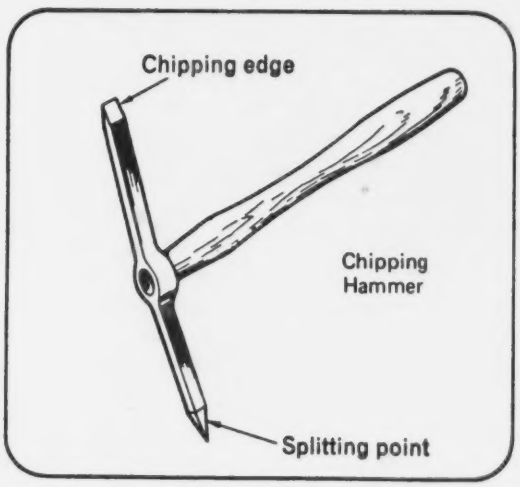
2. Connect other end of the welding lead to the output terminal on the power source.

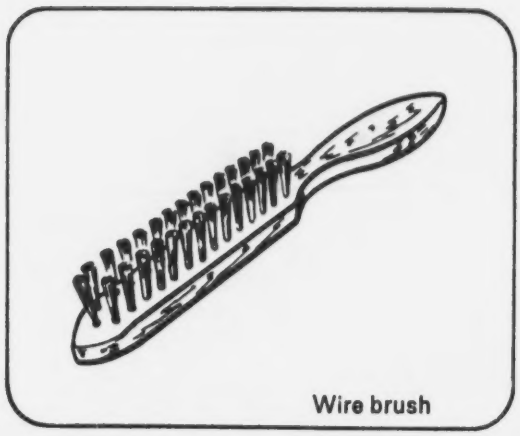
3. Connect one end of the return lead to an earth clamp or terminal on the workpiece.

4. Connect other end of the return lead to the return terminal on the power source.



Manual metal-arc welding circuit diagram



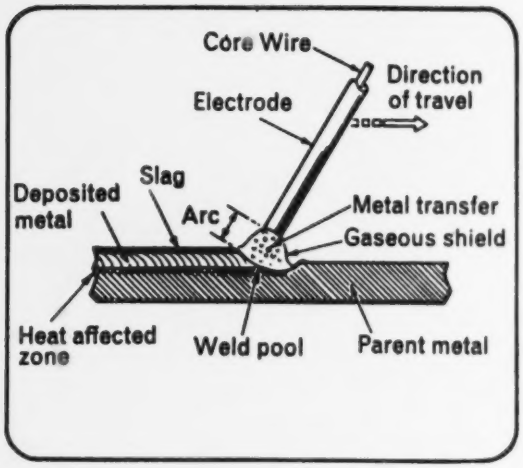


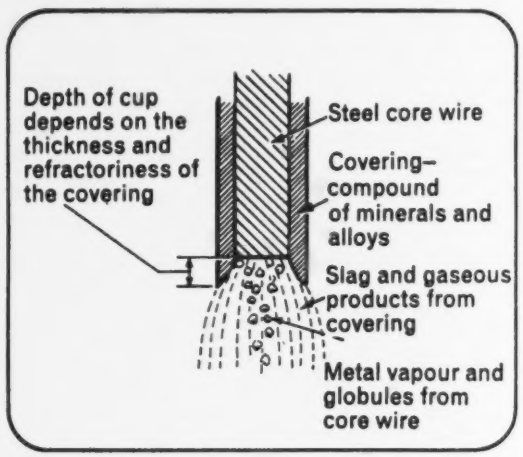
Operating the equipment

The following instructions apply to manual metal-arc welding only.

Always:

1. Comply with the prescribed safety precautions and fire prevention procedure.
2. Check that the return earth lead is firmly connected to bench or workpiece and to power source.
3. Check that the welding lead is connected to power source and that the connection to the electrode holder is tight and sound.
4. Check that the power source is switched on.
5. Use effective protective equipment and wear the necessary protective clothing.
6. Concentrate on watching the welding operation.
7. Have full control of the movements of the electrode and hold it steady.
8. Hold the electrode holder with just sufficient grip to give control – tight gripping will cause muscle fatigue.
9. Position yourself to avoid stretching and the risk of over-balancing.
10. Support the arm holding the electrode holder by keeping it near the body, but do not restrict freedom of movement.
11. Check that portable screens are in position. Warn unscreened observers before the arc is struck.
12. Ensure that the welding screen is in front of the eyes before striking the arc; keep it there until the arc is broken.
13. Place the electrode holder in a safe place when not in use.
14. Use goggles when chipping off hot slag.
15. Ensure that all slag and spatter is cleaned off fusion faces and previously deposited metal before starting the next run, using chipping hammer and wire brush.
16. Switch off power source when not in use.
17. Switch off mains supply to power source at end of work period.
18. Leave the work area in a tidy and orderly manner and ensure that equipment is properly stowed.




Depth of cup depends on the thickness and refractoriness of the covering
Steel core wire
Covering– compound of minerals and alloys
Slag and gaseous products from covering
Metal vapour and globules from core wire

The Welding Arc

When the current is switched on an electrode is placed in the holder and the electrode end is placed in firm contact with the workpiece (i.e. short circuited). Current will flow through the circuit.

This flow is interrupted by breaking the contact with the workpiece. When the gap is narrow, and if the open circuit voltage of the power source is high enough, the current leaps across the gap and creates an arc.

When the arc is struck the voltage falls to what is known as the arc voltage.

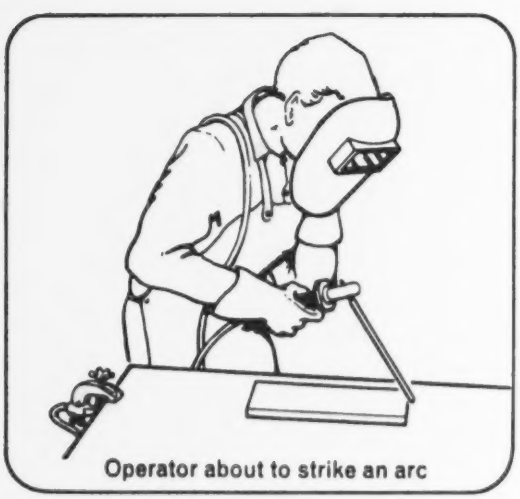
The arc voltage is between 20 and 25 volts for most types of electrodes at normal arc length.

The arc voltage depends upon:

1. The type of electrode used.

2. The length of the arc.

When the arc is made, the end of the electrode and the local area of the workpiece rapidly reach fusion temperature. The electrode core wire melts. The molten metal is transferred across the arc gap to fuse with the workpiece.



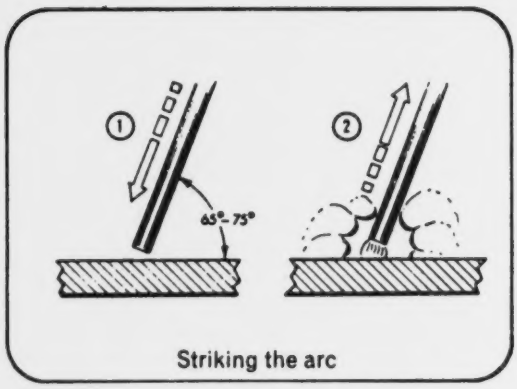
Operator about to strike an arc

Striking the Arc

Material	One piece of mild steel 10 mm thick. Min. size 15 cm x 30 cm.
Preparation	Clean surface
Electrode	4 mm Class 2
Current	150 – 170 amperes

1. Ensure that there is good electrical contact between the plate and the bench. The plate should be in the flat position.

2. Using gloved hand, insert the grip end of the electrode in the electrode holder.



Striking the arc

3. Point electrode downwards, and away from the body at an angle of $65^{o} - 75^{o}$ to the plate surface.

4. Lower the electrode holder until the electrode striking end is about 25 mm away from the plate at the point where deposition is to start.

5. With welding screen in position lower the electrode until the striking end touches the plate (use an action similar to that of gently striking a match).

6. Contact of the electrode end with the plate closes the electrical circuit and current flows.

7. Immediately withdraw the electrode a slight distance from the plate to establish the welding arc.

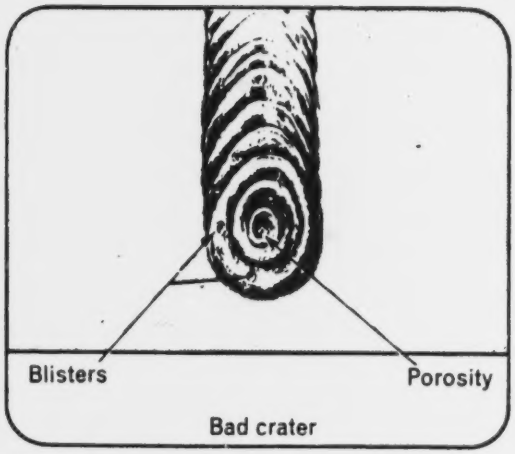
8. After a few seconds break the arc by withdrawing the electrode end smartly from the plate.

9. Repeat until skill in establishing the arc is attained.

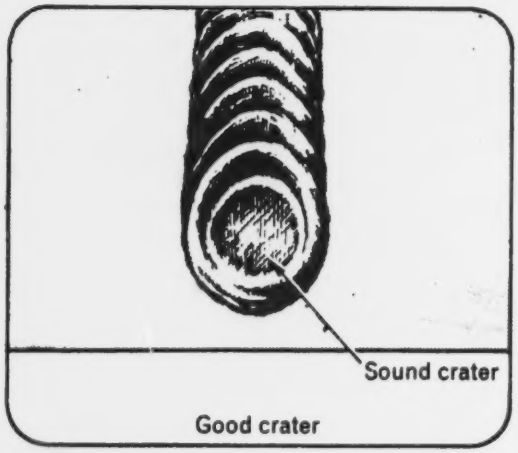
Difficulty is often experienced in making the arc. The electrode end may be withdrawn too far or allowed to fuse (or freeze) to the plate because it is not withdrawn quickly enough.

If freezing occurs give the electrode holder a sharp twist to wrench the electrode free. Keep the welding screen in front of the eyes.

If the electrode is not freed immediately open the electrode holder jaws and move the holder away (or switch off the welding current) and remove the electrode with a chisel.



Bad crater



Good crater

Breaking the Arc

A simple withdrawal of the electrode end will break the arc.

Before breaking the arc:

1. Pause with the electrode held in position long enough to build up the weld pool.

2. Move the electrode quickly sideways and away from the plate surface.

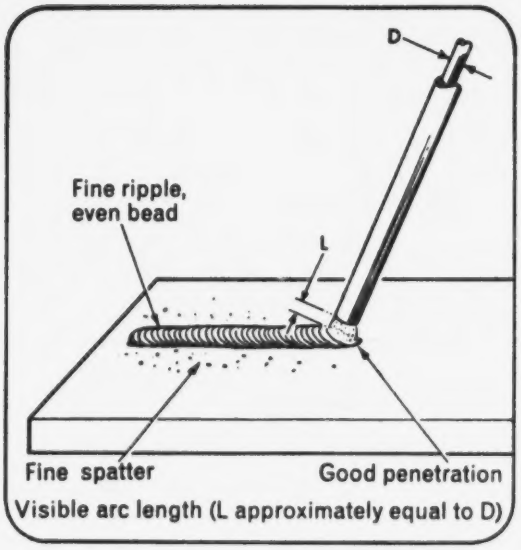
One will learn later how to strengthen the end of the weld run. The above procedure will avoid the formation of:

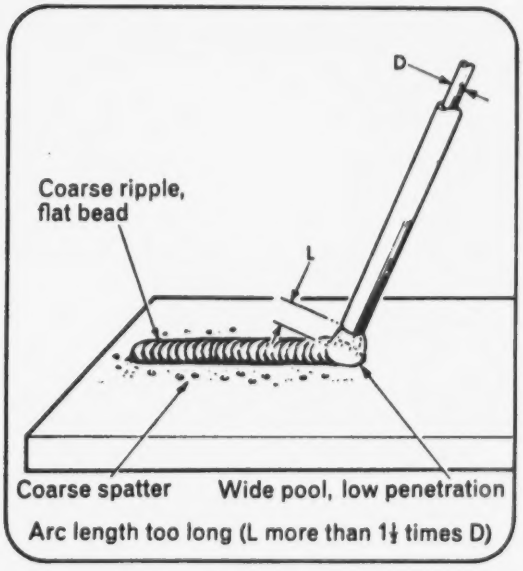
1. cavities,

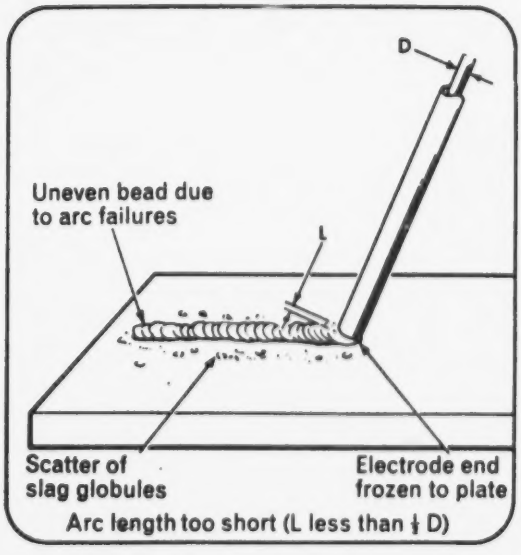
2. blisters,

3. porosity or fine cracks in the crater.

These result from premature or hasty breaking of the arc.







Deposition in Flat Position

Material	One piece of mild steel 10 mm thick. Min. size 15 cm x 30 cm.
Preparation	Clean surface
Electrode	4 mm Class 2.
Current	150 – 170 amperes

1. Using the method in EP1 establish the arc at the left-hand edge.

2. Move the electrode holder progressively towards the plate to maintain the arc.

3. Combine this with a progressive movement along the plate at a rate of about 15 cm per minute.

4. The direction of deposition should be either from left to right or from the starting point towards the person.

5. Aim to synchronize these movements to produce a bead of deposited metal on the surface of the plate. Avoid producing a large pool of molten metal in one spot.

6. The arc length, i.e. the distance between the electrode end and the surface of the weld pool, should be approximately 4 mm (about the same as the diameter of the core wire).

7. Watch the arc length and keep it as constant as possible.

8. Keep an even rate of travel to ensure an even deposit.

9. The length of movement along the plate should be about 23 cm in the time taken to deposit 42 cm of electrode, i.e. the run length per electrode.

Arc Length

1. If correct the electrode metal will be deposited in a stream of small particles.

2. If too long the arc will be noisy; deposition will be erratic; large globules of metal will be ejected; excessive spatter will result.

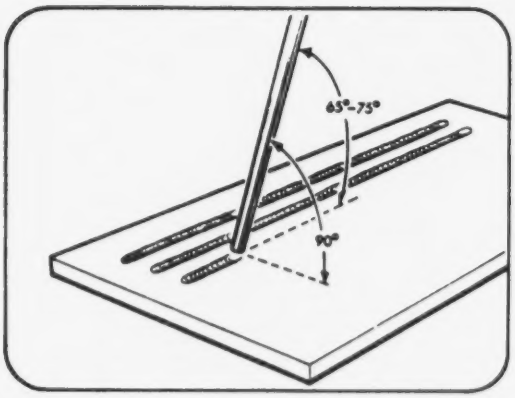
3. If too short, it will be difficult to maintain the arc; freezing of the electrode end in the weld pool may occur.

Slag

Whilst maintaining the arc and controlling the rate of travel of the electrode learn to distinguish between the molten metal and molten slag. Slag appears to be cloudier but brighter than the clear weld metal. It will flow away and float to the top of the cooling metal if:

1. The electrode end directed at the correct angle to the plate surface.

2. If the correct welding conditions and techniques are used.



Depositing Straight Runs

1. Using the method on page 49 establish the arc at the left-hand edge.

2. Move the electrode end in a straight line along the plate.

3. Develop a sense of direction with the welding screen in position.

4. Weld first on one side of the plate and then on the other side to keep it fairly level.

5. The plate may be water (or air) cooled between runs provided it is allowed to dry off.

6. Leave a space of about 12 mm between the parallel runs.

7. Use different rates of travel to see the effect of the change in speed on the shape of the weld bead.

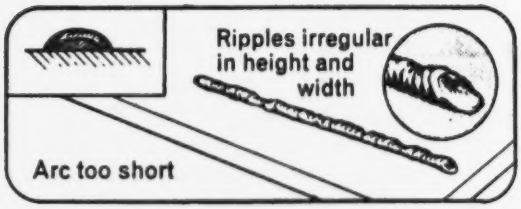
8. Use welding currents about 20% lower and higher to see the effect of the change in current on the appearance of the weld bead.

Visual Examination

Examine deposited beads and note any variations in width, thickness, depth of fusion, and length of runs.

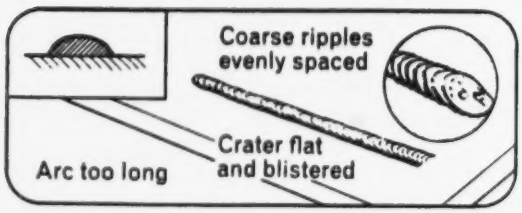
These may be caused by intentional or unintentional variations in arc length, rate of travel, or welding current. (See next page.)

Assess causes and take corrective action until straight, parallel runs of even shape and uniform width can be produced.

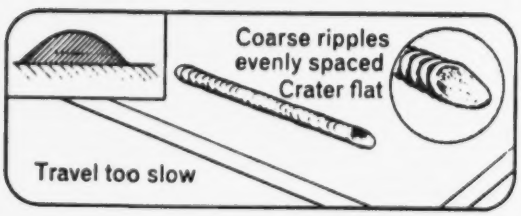


Effect of variation in procedure

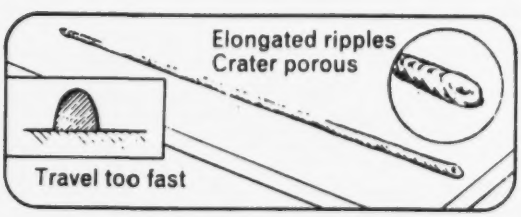
1. Too short an arc length will cause irregular piling of the weld metal.



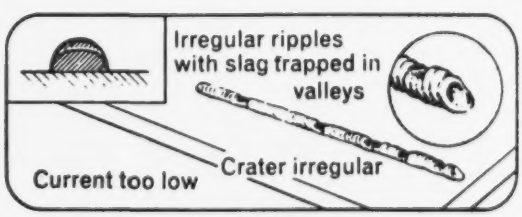
2. Too long an arc length will cause the deposit to be coarse rippled and flatter than normal.



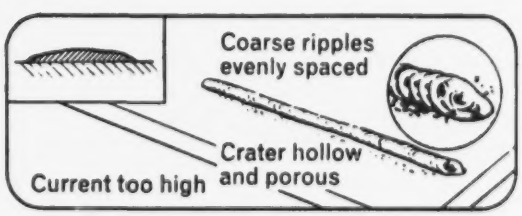
3. A slow rate of travel gives a wider, thicker deposit, shorter than normal length; too slow a rate of travel may allow the slag to flood the weld pool causing difficulty in controlling deposition.



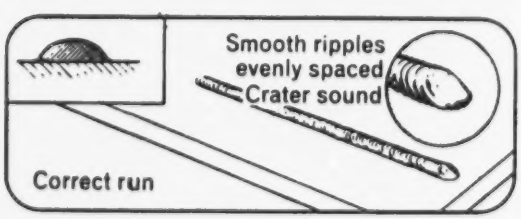
4. A fast rate of travel gives a narrower, thinner deposit, longer than normal length; too fast a rate of travel may prevent adequate interfusion with the parent metal.



5. A low welding current tends to cause the weld metal to pile up without adequate penetration into the parent metal; too low a welding current makes the slag difficult to control.



6. A high welding current gives a deposit that is flatter and wider than normal with excessive penetration into the parent metal; too high a welding current causes considerable spatter.



7. With the correct arc length; correct rate of travel; correct angle of electrode; correct welding conditions and technique; the run deposited metal will be regular in thickness and width, with a neat finely rippled surface, free from porosity or any slag entrapment.

Tack welds

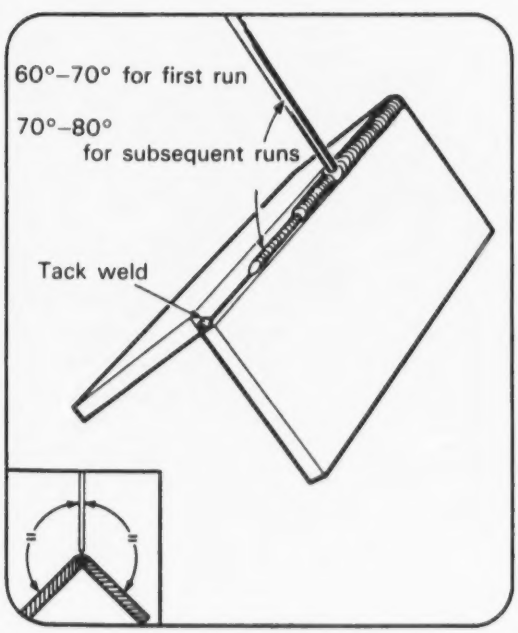
A tack weld is a short weld used to help assembly and to maintain the position of parts during welding.
Tack welds should be between three and four times the plate thickness, up to a maximum length of 35 mm at the ends of the joint.
For intermediate tack welds the length should be between two and three times the plate thickness, up to a maximum length of 35 mm.

Pitch of tack welds

For mild steel plates, of 3 mm thickness, the pitch (ie. distance between centres) of tack welds in butt joints should be 150 mm. The pitch should be increased by about 15 mm for each 1 mm increase in plate thickness, up to a maximum of 600 mm for thicknesses of 33 mm and above.
For lengths less than twice the normal pitch distance, end tack welds only are required.
The above pitch distances should be doubled for fillet-welded T-joints.

Corner joint—Flat position

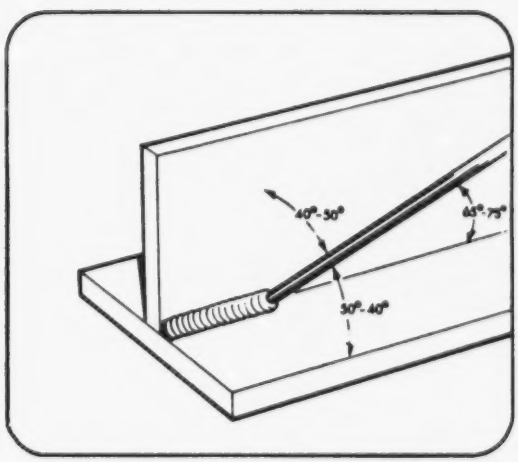
Material	Two pieces of mild steel 10 mm thick. Min. size 200 mm x 75 mm
Preparation	Square edge
Assembly	Tack weld both ends to give included angle of 90°: 0·75 mm–1·5 mm gap at root
Electrode	4 mm Rutile
Current	150–170 A



1. Deposit the root run, without weaving, with the electrode angle at 60°–70°.
2. Adjust rate of travel so that metal is deposited equally on lower portion of each fusion face and just penetrates the root.
3. Deposit a second run in the same direction but this time, using slight transverse weaving motion, with the electrode angle increased to 70°–80°.
4. Make a slight pause in the weaving motion at each fusion face. This will help to prevent undercut and secure a flat weld face.
5. Reduce welding current slightly.
6. Complete the weld with a third run deposited in a similar manner to that of the second run.
7. Take care to only just fuse the top edges of the fusion faces and to obtain a slightly convex weld profile.

T-Joint (Horizontal/Vertical Position)

Material	Two pieces of mild steel 12.5 mm thick. Min. sizes 5 cm x 30 cm.
Preparation	square edge
Assembly	tack weld both ends so that the plates form an inverted T without any gap between the plates.
Electrode	1st side 4 mm Class 2 2nd side 5 mm Class 2
Current	1st side 160–170 amperes 2nd side 200–220 amperes



1. Deposit a fillet weld with the 4 mm electrode.

2. Hold the electrode at an angle of $40^{o} - 50^{o}$ to the vertical plate and at $65^{o} - 75^{o}$ to the line of the joint, without weaving.

3. Counteract any tendency of deposited metal to fall towards the horizontal plate by slightly increasing the electrode angle to the vertical plate.

4. Adjust rate of travel so that a weld of equal leg length approximately 6 mm is deposited.

5. After joint has cooled sufficiently to be handled weld the other side with the 5 mm electrode, using same technique but slightly faster rate of travel to deposit same size of weld.

Visual Examination

Saw through the welded assembly so that the transverse cross-sections of the welds can be examined.
The profile of the weld should be slightly convex, without any undercutting at the toes of the weld. Penetration to the root without any trapped slag should be achieved. At this stage, and using this type of electrode, penetration beyond the apex of the angle formed by the fusion faces should not be expected.

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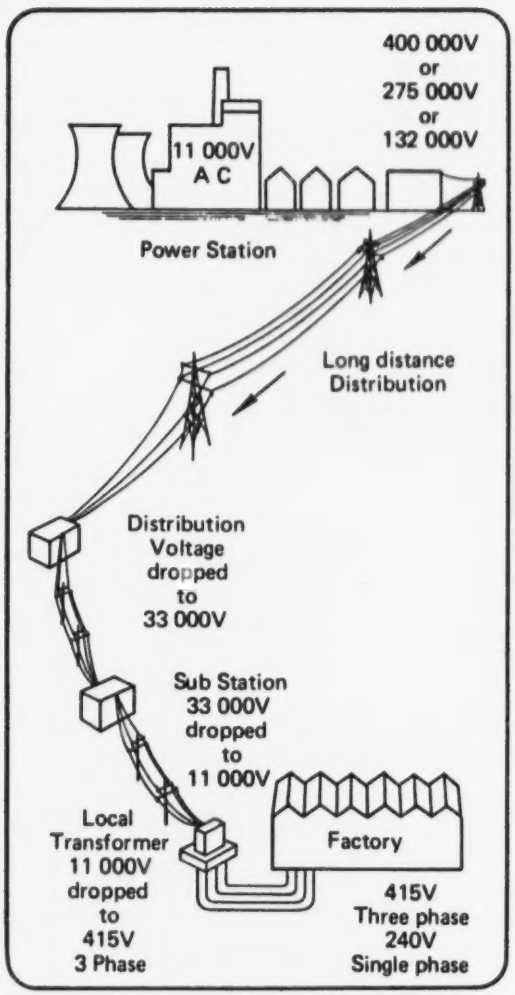
General Information

Electric power is distributed from power stations over the National Grid system at very high voltages (up to 400 KV). These high voltages are reduced at suitable points to lower voltages by means of transformers. Electric power which is supplied to factories, workshops and houses is supplied from a local transformer which reduces the voltage to a 415V 3 phase supply. In Great Britain the standard electric power supply has an alternating voltage with a frequency of 50 hertz (cycles per second).



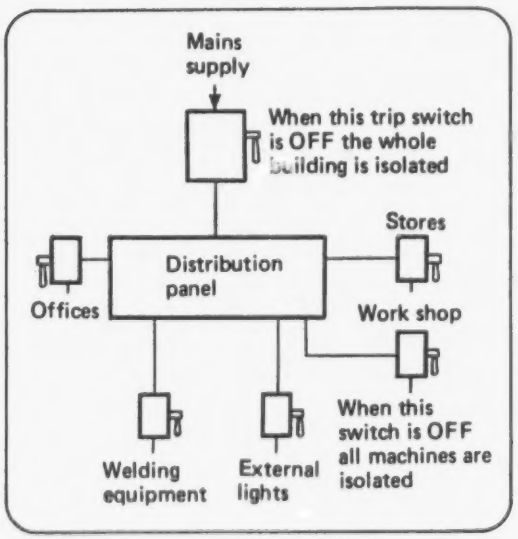
Electric Power

Electric power for driving machines is supplied from a local transformer which gives a three-phase output, 415 volts 50 hertz. The power is supplied to the plant by an electric cable which contains four insulated conductors, colour-coded red, yellow, blue and black. The black wire is called the neutral and is added to enable a single phase supply at 240 volts to be distributed.

Protective Devices

Electric current is carried by electrical conductors. These will be cables, wires or metal strips each with suitable insulation to prevent short circuits or accidental earthing of live conductors. The resistance which conductors offer to the flow of electric current causes heat to be generated. If the flow of electricity in a circuit suddenly increases, the heat in the conducting wires increases, and could cause the insulation to burn, resulting in damage to equipment, and possibly causing a fire. All electric circuits must therefore be protected against current overloads, and quickly isolated from the supply when a fault develops.

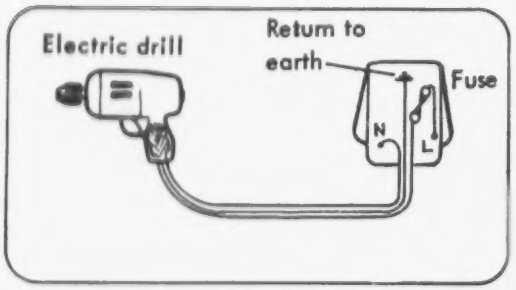
Such protection can be given by the use of:
manual trip switches;
fuses;
automatic trip switches (re-setting devices)
circuit breakers.



Manual trip switches

Manual trip switches can be located at any point in the circuit which is convenient, and are used to isolate equipment from the supply if a fault should develop. An example of such switches is the emergency stop button which isolates sections of machine tools in the First Year workshop.

The block diagram illustrates how these might be located and used.



Fuses

Individual circuits should have a fuse fitted in the supply line to the equipment. The fuse may be of the cartridge type which is held in position by two spring clips, or it may be a piece of wire joining two points in the circuit. Fuses are rated in amperes and the rating chosen is such that, in the event of an overload of current, the fuse wire will melt and break the circuit before any damage to the circuit wiring or equipment occurs. In the event of a fuse blowing, the appropriate manual switch must be switched off and the fault rectified before replacing the fuse. When a fuse is changed, the correct rating must be used. It is dangerous, and could be expensive, to fit a replacement fuse with a higher rating than the one removed.

Safe Working Practice
The trainee must be fully aware of all possible hazards resulting from the use of electricity at every stage of his work.

Safety

1. Faulty electrical equipment must not be used and must be reported immediately.

2. Electrical equipment must not be touched with wet hands, in case there is a fault in the equipment.

3. Frayed wires are dangerous and must be reported.

4. Electrical connections must always be made by an authorised electrician.

5. Electrically driven hand tools must be properly earthed. If the earth wire is not connected to the earth pin, the outer casing can become "live" and give a shock which could be fatal. If in doubt, consult an instructor.

6. Power tools must never be connected to a lamp socket as these have no earth connection.

7. Electrical hand tools must be properly insulated.

The instructor will explain what has to be done in the case of emergencies or accidents.

Personal Injury
Ring for immediate help. Treat bleeding and shock.

Fire
1. Know position of nearest exit, alarm, extinguisher. N.B. A special extinguisher is required for electric fires.

Electric shock
1. Switch off power or drag victim away from live parts using non-conducting material such as a length of wood, bakelite tubing, dry material, e.g. a scarf.
2. Administer artificial respiration and send for expert help.

The instructor will ensure that the trainee is made aware of any risks existing in a particular department. He will also point out the appropriate safeguards which are provided and safety precautions which may be observed.

In particular, attention must be drawn to relevant passages of the Factories Act, statutory requirements or regulations, and to safety posters displayed around the workshop.

Electrical interference
Unauthorised interference with electrical apparatus, is both illegal and extremely dangerous and any risk taken might be the cause of instantaneous death.

Do not take liberties with electricity.

Never interfere with levers, knobs, push-buttons or switches on machinery or electrical equipment which you have not been trained to operate.

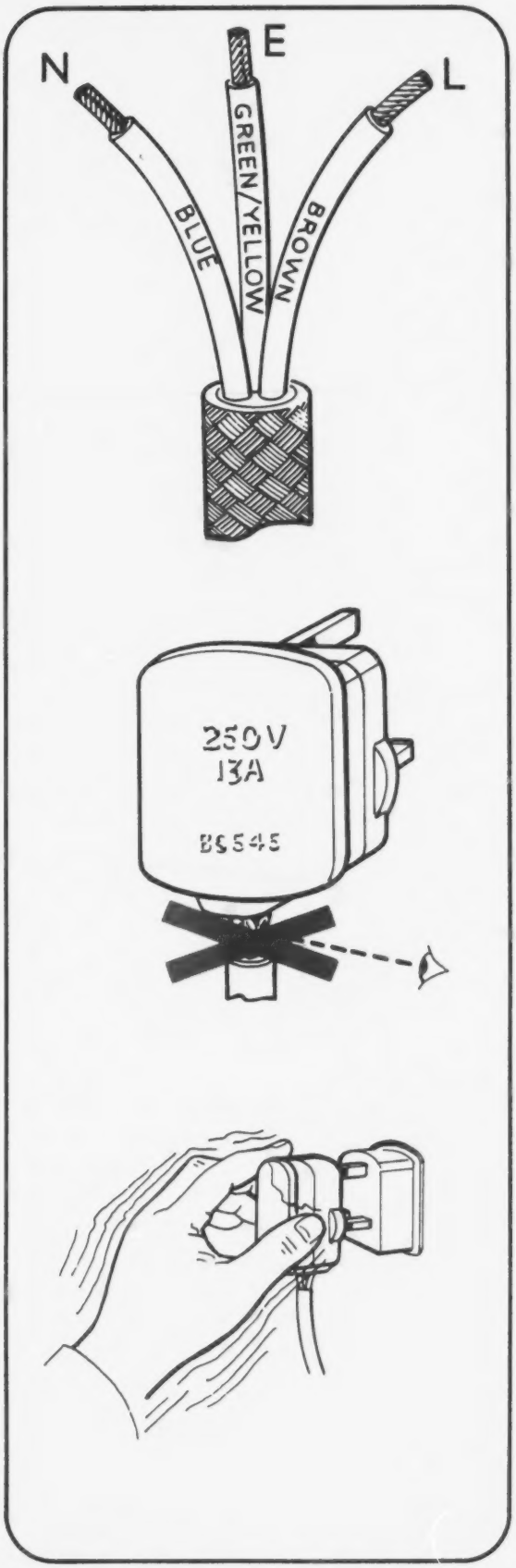
If you wish to know how such equipment works, ask somebody who does know.
Do not experiment.

Authorised working
Before working on electrical apparatus, switch off the power supply and make sure that it cannot be accidentally switched on. Disconnect from supply, if possible.

Earth high voltage circuits or capacitors to remove static charges after they have been disconnected.

Check wiring or components with a voltmeter or a neon test lamp before touching equipment.
Do not touch with the finger – you will not be quick enough, do not take the risk.

All exposed metal parts should be efficiently bonded together and earthed.



Safe use of electricity
Note the colour code for 3-core cables used with portable tools etc.,

LIVE wire	BROWN
NEUTRAL wire	BLUE
EARTH wire	GREEN/YELLOW

Ensure that these are connected correctly.
See:–

R.o.S.P.A. Publication "Safety for Industry"

Electricity (Factories Act) Special Regulations.

Statutory Rules and Order 1908 No. 1312

Statutory Rules and Orders 1944 No. 739
Electricity Regulations 1908 (Competent Persons Exemption) Order 1968 No. 1454.

If a 3-core cable moves freely at its point of entry to a plug or appliance, or if the individual insulated wires are visible, a dangerous condition is developing.
See that it is corrected at once.

Check the continuity of earth wires at regular and frequent intervals.

Report all defects at once.

e.g. cracked or perished insulation,
loose pins on plugs,
badly fitting plugs and sockets,
damaged switch covers,
detached earth wires.

If defects are not removed they are accepted as normal.

They become ignored.

They cause accidents.

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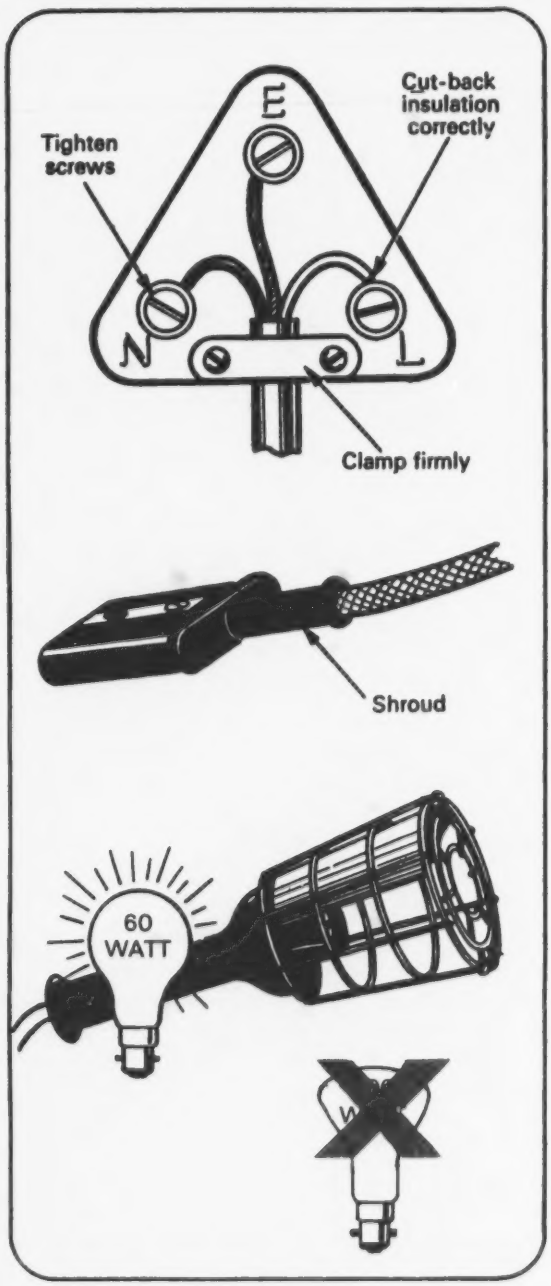
Electrical fire risks
Observe all Regulations relating to the safe use of electricity and to electrical fire risks.

Fires may be started by:–
(a) Overheating of cables, appliances and plugs.

(b) Sparks produced under operating conditions, e.g. contactors and commutators.

(c) Sparks which result from a circuit being broken.



Connections and terminals
There is an electrical fire risk if:–
(a) the cable current-carrying capacity is inadequate:

(b) the capacity of the plug is inadequate:

(c) the insulation is cut back too far:

(d) the conductor is damaged while cutting back the insulation:

(e) the connections are not tight:

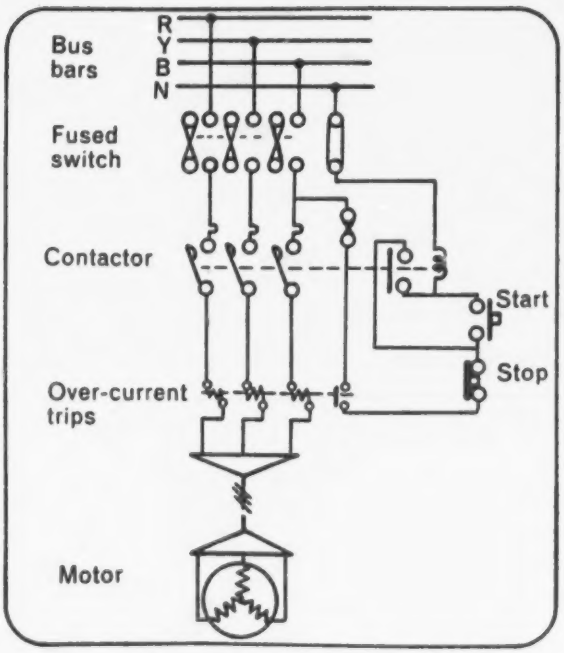
(f) the cable is not adequately supported at the point of entry to the plug or to the appliance.

When a reinforcing rubber shroud is provided, ensure that it is used.

Inspection lamps
(a) Always fit a suitable bulb to an inspection lamp.

The use of a small modern high-power bulb may cause serious overheating to the lamp holder and may damage the insulation on the wires.

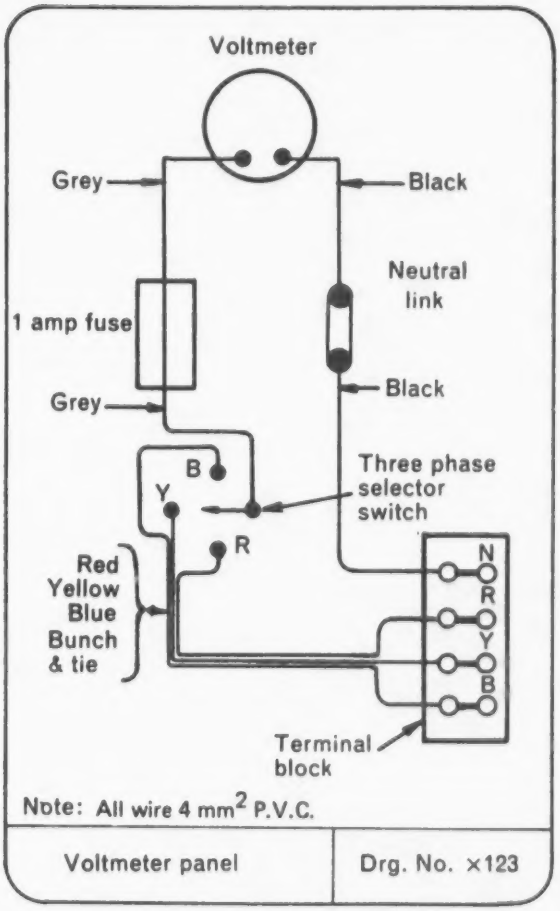
(b) Do not rest the lamp on flammable materials as the high surface temperature of the bulb may cause a fire.



Electrical Engineering Drawings

Electrical wiring diagram

A wiring diagram indicates all the wiring between parts and may show their layout. Interconnections may be tabulated.



Electrical wiring layout

A wiring layout shows the physical layout of the wiring and often includes details of colour coding or numbering of wire ends.

Typical Symbols to BS 3939

Symbol	Description
~ 50Hz	Alternating current 50 cycles per second
	Conductor
///	3 conductors shown by one line
	One wire crossing another
	One wire joining another
or	A fuse
	A Transformer single phase
	3 phase Transformer connected delta/star

PVC	—Reasonably cheap, resistant to corrosion
RUBBER	—Very cheap, perishes
P.T.F.E.	—Withstands high temperature, expensive
ENAMEL	—Only a very thin coat required

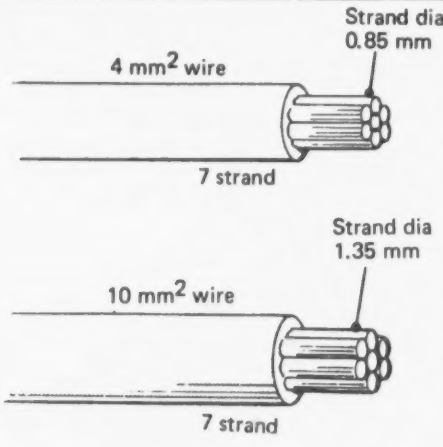
NOMINAL CROSS-SECTIONAL AREA (mm^2)	Wire dia (mm)
1·0	1·13
1·5	1·38
2·5	1·78

Common wire insulation materials
P.V.C., rubber, P.T.F.E. and enamel is widely used.

Common wiring used

1. Single Strand Wire

Single strand wire is used where rigid wiring is required.



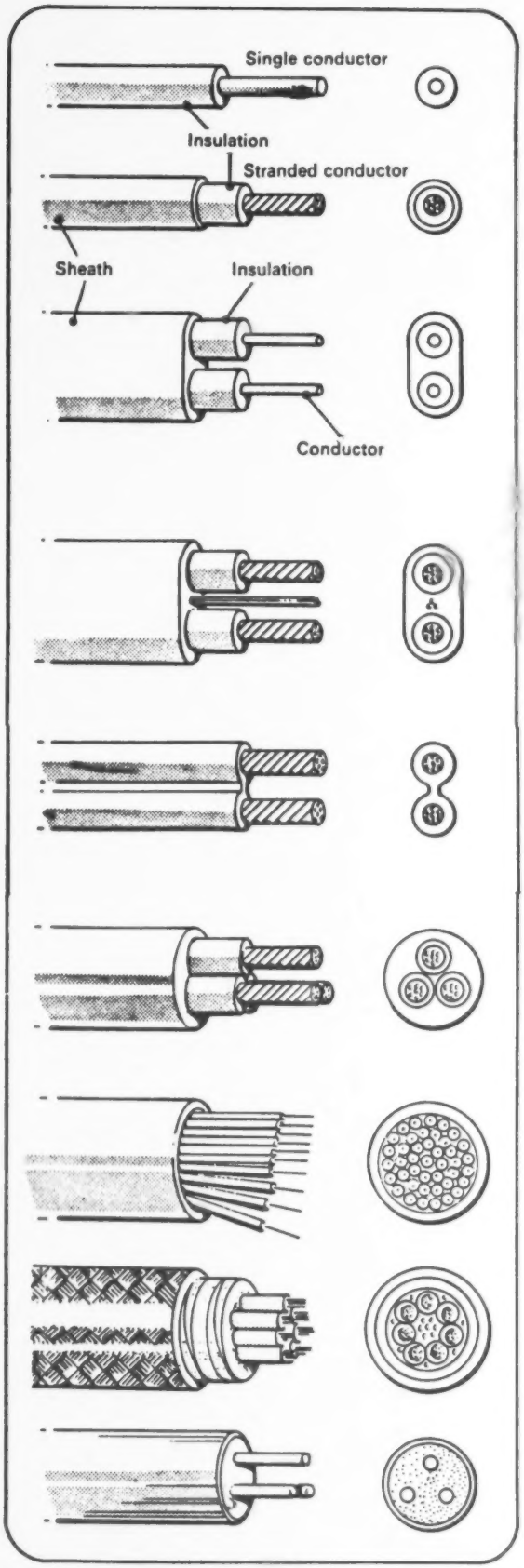
2. Multi-strand wire

Multi-strand wire is used where flexible wiring is required.

Both single and multi-strand conductors are classified by the nominal cross-sectional area in mm^2.

Colour code
For general use, the colours of core insulation are laid down in the "Regulations for the Electrical Equipment of Buildings" issued by the Institution of Electrical Engineers.

	Non-flexible cable	Flexible cable or cord
Earth Wire	Green/Yellow	Green/Yellow
Live side of 1-phase a.c.	Red	Brown
Neutral of 1-phase or 3-phase a.c.	Black	Blue



Types of Cable

Single conductor, single core, insulated, non-sheathed.

Stranded conductor, single core insulated, sheathed.

Two-core flat, insulated and sheathed (also called flat twin).

As above with an uninsulated earth continuity wire in same sheath.

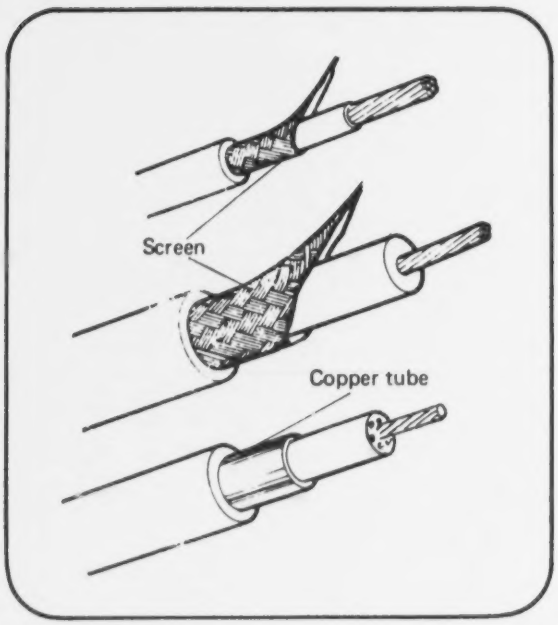
Parallel twin, cores easily separated without damage to insulation of either.

Three-core, insulated, sheathed, unarmoured.

Multi-core, insulated, sheathed paired conductors.

Multi-core, insulated, flexible cable, braided sheath.

Three-core mineral insulated copper clad.

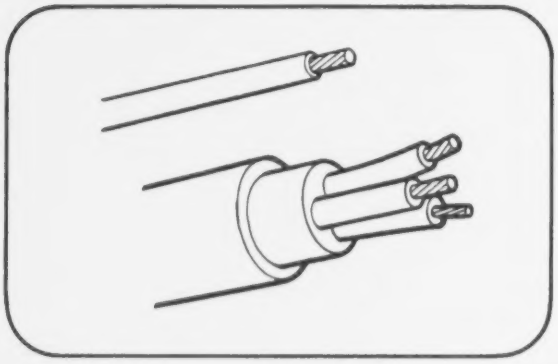


Co-axial cable
This is screened cable with a single central conductor of stranded or single wire surrounded by concentric layers of insulation and screening.

For radio frequency applications, a special high quality central insulation is used, which is much thicker.

For very high frequencies, the outer conductor may be continuous copper tube.

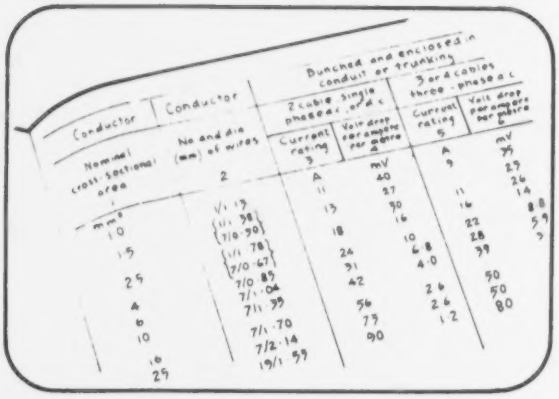
Current carrying capacity
This is the maximum permitted current that a conductor can carry. A greater current would cause overheating of wire and insulation and a fire could result.



In a 3-cored cable, the live and neutral conductors must each be capable of carrying the normal load current. The earth conductors must be capable of carrying the maximum fault current.

The current carrying capacity of a conductor is less than when it is part of a cable.

When two or more cables are run within the same conduit or trunking, their current carrying capacity is reduced.



Wire tables
The I.E.E. wiring regulations contain tables showing the current carrying capacities of wires and cables.
e.g. P.V.C. single-core in conduit 4 mm^2 carries 24 amps.

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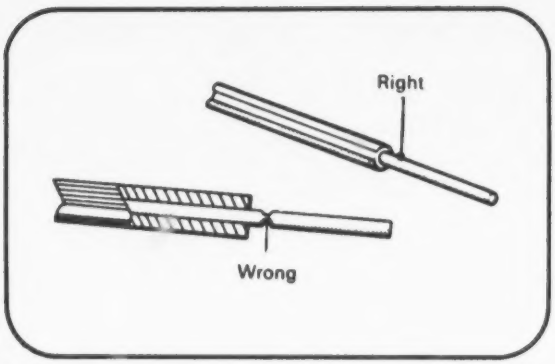
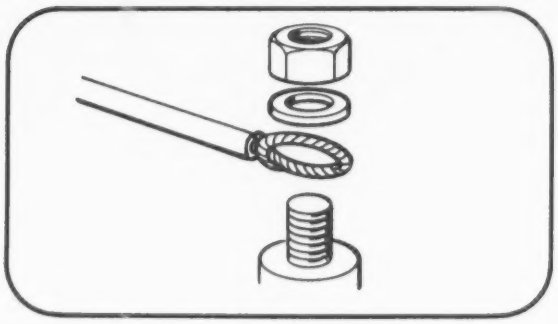
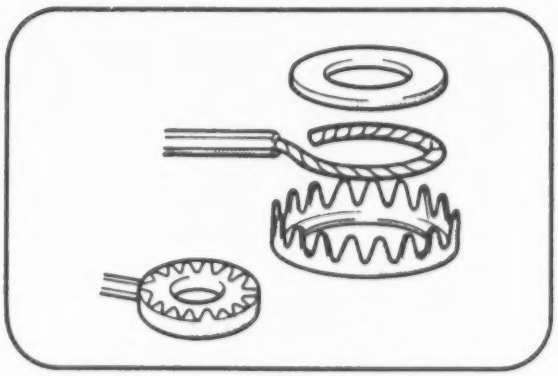
Terminations (All Types of Cable)



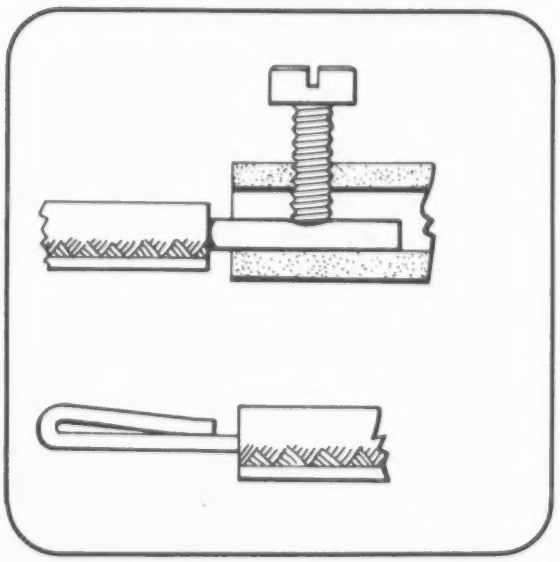
Cut back insulation to a suitable distance, taking care not to damage the conductors. A conductor which is nicked with a knife, or even grooved with a blunt cutting edge, is much more likely to fracture in service than an undamaged one.



For small cables, single or twisted strand conductors may be formed into a loop with round-nosed pliers. Ensure that the direction of the loop is such that tightening nut and washer cannot cause the loop to open.
(Dipping the loop in solder makes it stronger but causes loss of flexibility and failure may occur under vibration.)

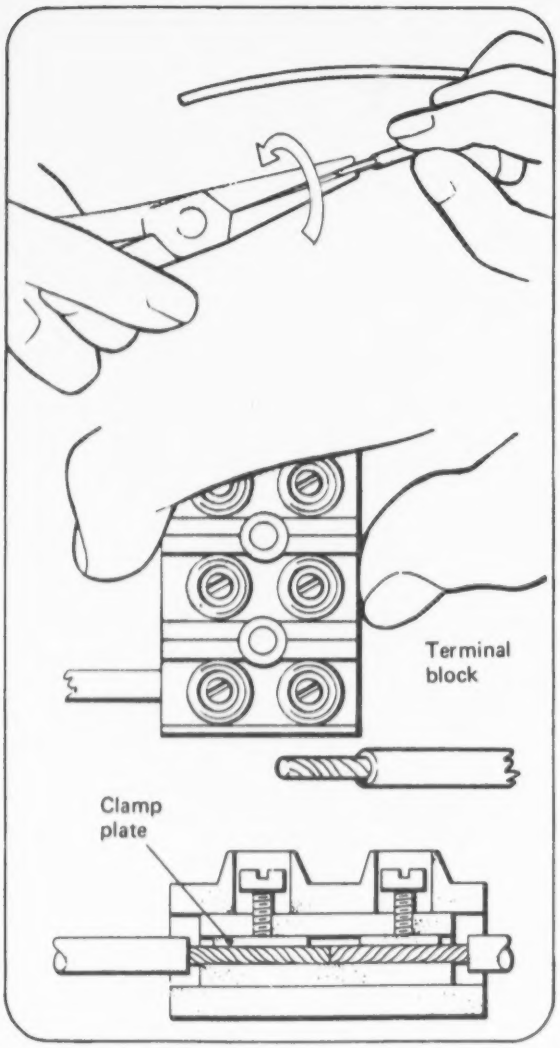


Use a special claw washer to get a better connection. Lay the looped conductor in the pressing. Place a plain washer on top of the loop and squeeze the metal points flat using the correct tool – not ordinary pliers.



When a pinch screw is used to hold a wire or cable in position, take care not to damage the conductor by excessive tightening.

A single-wire conductor should be doubled back on itself so that the screw squeezes two strands and is less likely to cause damage.

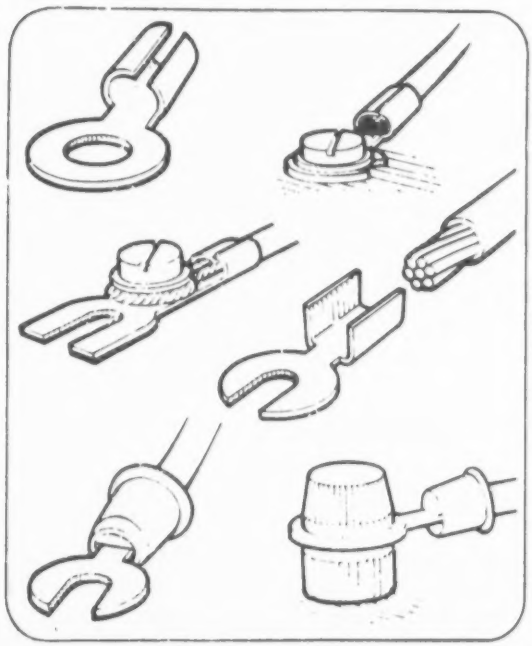


A stranded conductor should:

(a) have its strands twisted together tightly – using pliers – in the direction of the existing twist (or 'lay') of the wires.

(b) be inserted as far as possible into the connector so that the pinch screw does not clamp the end of the conductor.
(If it does, the strands will try to untwist and the connection may eventually become loose.)

Terminal Blocks
Some types of terminal blocks have clamp plates which press against the conductor and prevent damage being caused to the conductor by the screw.



Wiring Accessories

Cable ends

These are used when the wire has to be connected to a screw terminal. A suitable size must be chosen to fit cable and terminal. If frequent disconnection is likely, the open-ended type of tag is used.

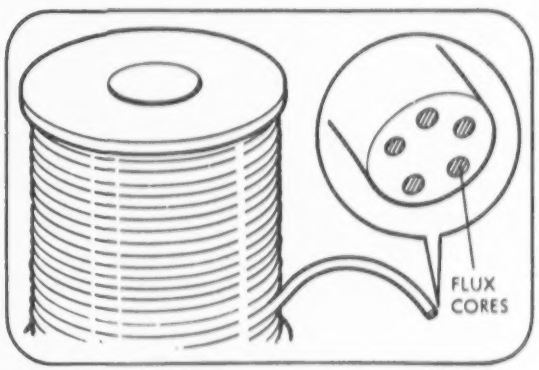
Most tags are flat to allow panel fixing. The insulated type require the clearance given by pillar terminals.

Connecting tags may be soldered or crimped to conductors.

General Information
Soft solder is an alloy of tin and lead. It is used to join metals together by being melted on to a joint to provide a film that unites the surfaces. The process of soldering does not melt and fuse together the two joining surfaces, but makes the solder flow between and actually combine with the surfaces of the metals to be joined.

Electrical Work
For soldering a wire to a terminal a solder is needed which will solidify rapidly.

This shortens the time taken to perform the operation and lessens the risk of components becoming displaced before the solder cools. The solder used in this work is known as *Tinman's solder.*



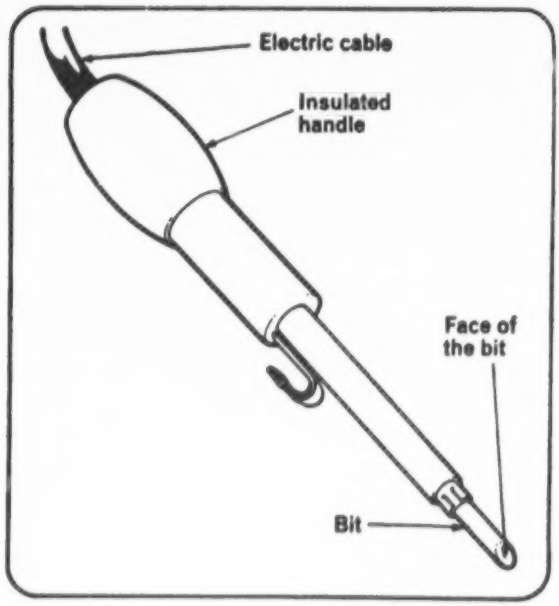
Cored Solder
Solder used for electrical/electronic work is usually in cored form having a core or cores of resin flux.

Fluxes
Only non-corrosive fluxes may be used in electrical/electronic work. There are two types of non-corrosive flux: resin fluxes and active fluxes.

Resin fluxes have two purposes:
to flow quickly over the joint, and speed up the transfer of heat to the work, or to protect the metal from the atmosphere, and prevent the metal from oxidising when it becomes hot.

Active fluxes have an additional purpose – to clean the joint by removing grease and oxidised film from the surface of the metal. Although active when hot they are non-corrosive at room temperature.

Flux is sometimes obtained as a paste, to be painted on to the joint before soldering. For electrical/electronic work, it is more convenient to use cored solder.

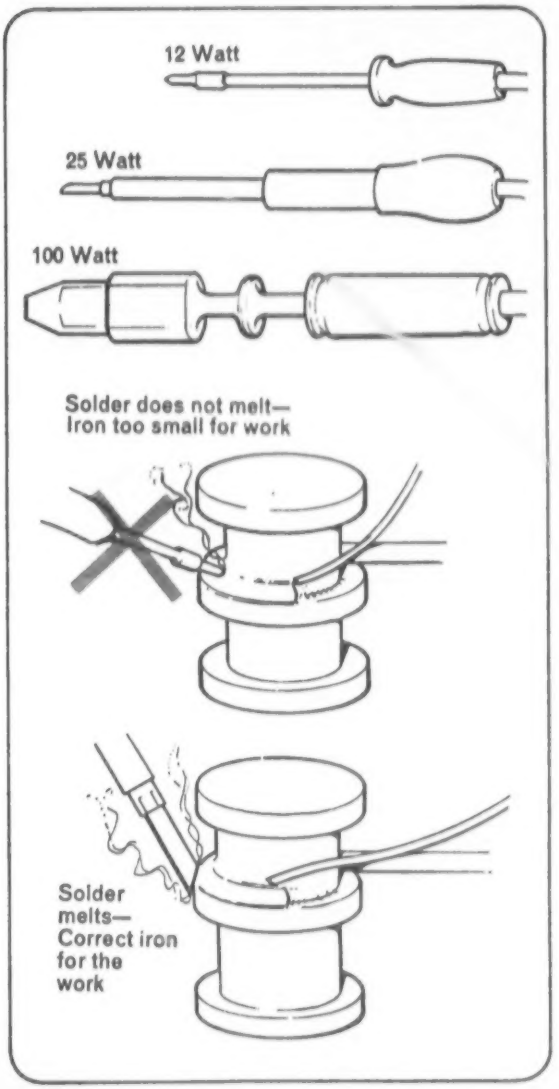


The Electric Soldering Iron

The heating element in the iron is heated by electric current passing through it.

The bit is heated by the heating element.

The face of the bit is the part of the iron used to make contact with the surfaces to be soldered.



Voltage

A soldering iron is designed to operate at a specified voltage. This can be either:

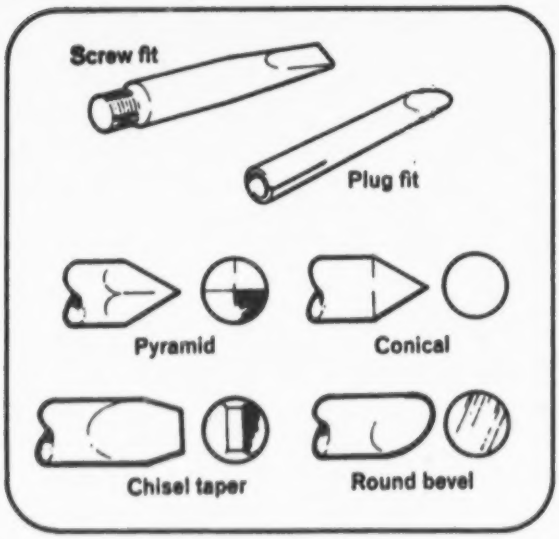
1. The mains supply, or

2. A low voltage supply.

Power rating

Soldering irons are available in a range of power ratings. The power is specified in watts.

Select an iron with adequate power for the size of the work.



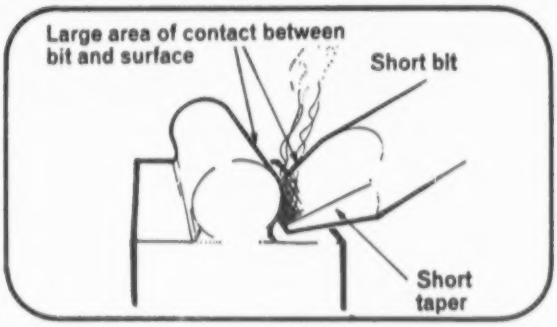
The Bit

Most bits are made of copper because it is a good conductor of heat.
The face of the bit may be either:

1. Unplated, or

2. Iron plated.

Iron plated faces do not wear out as rapidly as unplated faces.
Most irons are constructed so that the bit can be changed.
Different shapes of bit are available.

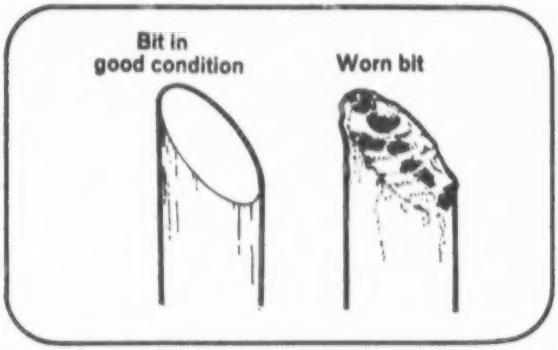


Selecting the bit
Select the bit to give the best compromise between:

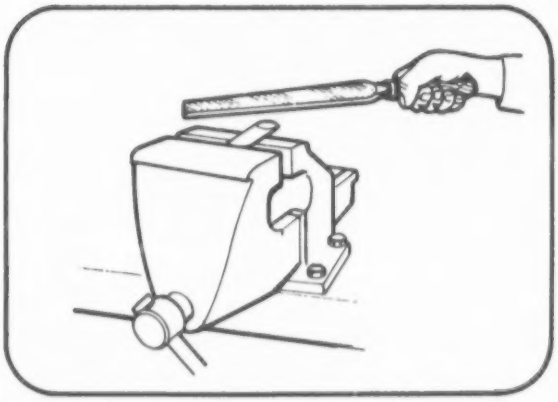
1. The best approach to the work.

2. The shortest bit and bit taper.

3. The best contact with the surfaces.



Care of the bit
Unplated bits quickly become pitted, mis-shapen and covered in oxide. If the iron is in constant use this will occur within a few hours. To make a good soldered joint the bit must be maintained clean, smooth, and to the correct shape.



Dressing the bit
To dress an unplated bit:

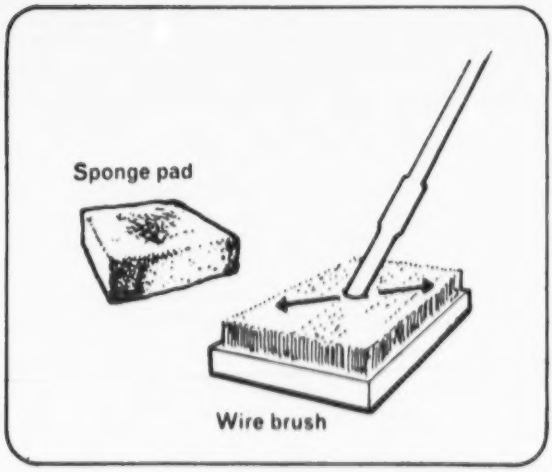
1. Switch off, unplug the iron and allow it to cool.

2. Remove the bit from the iron.

3. Mount the bit in a vice.

4. File to shape.

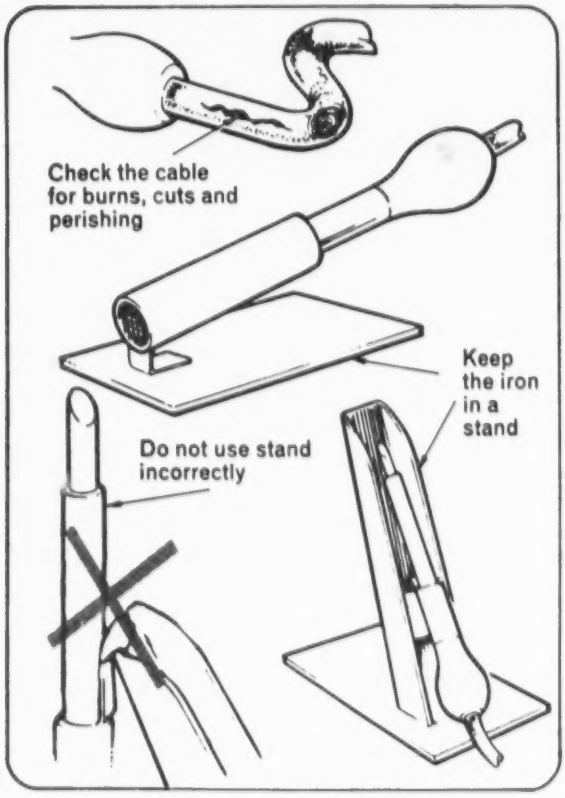
Do not file the bit in an electronic assembly area. Copper dust from the bit may settle in equipment and cause a short circuit.
Iron plated bits must not be filed. Renew when worn.



Cleaning the bit

Clean the bit frequently. With the iron hot, rub the face of unplated bits on a wire brush or special sponge pad.

Iron plated bits must not be cleaned on a wire brush. Rub on a sponge pad.



Safety

Soldering irons can be dangerous

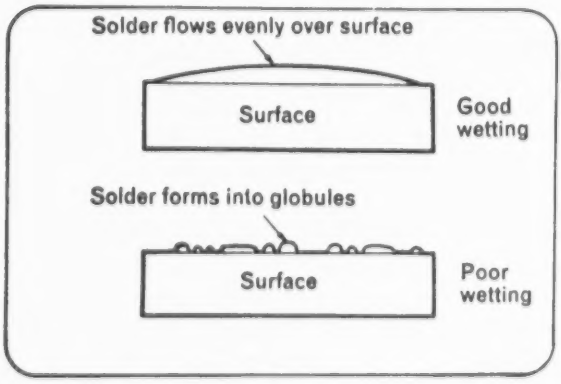
1. Inspect the iron regularly for physical damage, especially the lead. Report any damage.

2. Keep the iron in a stand when not in use. This prevents burns and fires, and protects the iron from damage.

3. Do not subject the iron to rough treatment.

4. Keep the iron away from all parts of the body and from its own lead.

5. A proper earth connection must be made to all mains irons. If you suspect that an iron is not earthed, do not use the iron. Notify your instructor at once.



Wetting

To make a good joint the solder must flow evenly over and between the surfaces to be soldered. Wetting is a term used to describe the extent to which this occurs.

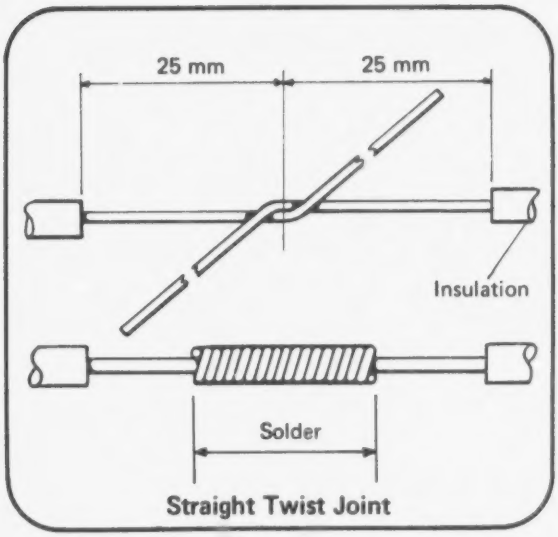
Good wetting results if:

1. The surfaces are clean.

2. Sufficient flux of the correct type is used.

3. The surfaces are hot enough.

4. The surfaces have been tinned.



Straight Twist Joint

Types of Soldered Joints

Straight twist joint

1. Remove 75 mm of insulation from end of each wire.

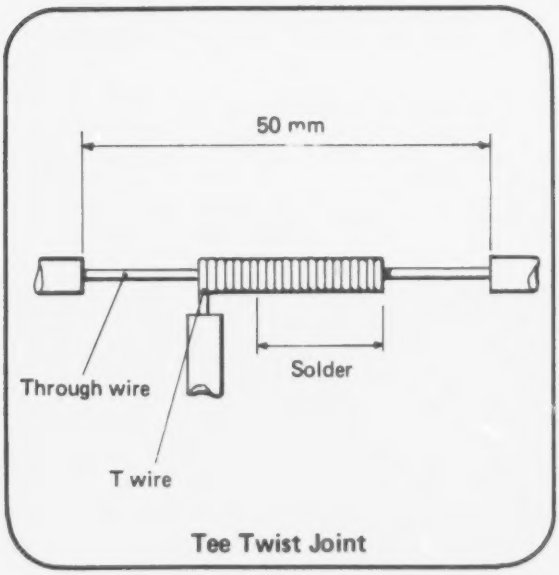
2. Clean and tin bare ends of wires.

3. Cross wires 50 mm from ends.

4. Twist each wire tightly round the other, in opposite directions, keeping each turn of wire closely to next.

5. Trim ends.

6. Solder joint.



Tee Twist Joint

Tee twist joint

1. Remove 50 mm of insulation from through wire without cutting conductor.

2. Remove 50 mm of insulation from end of T wire.

3. Bind T wire tightly round through wire, from left to right.

4. Solder joint, leaving first two or three turns free to allow flexibility.

Britannia joint (used when conductors are under tension).

1. Remove 75 mm of insulation from end of each wire.

2. Clean and tin bare ends of wires.

3. Bend each wire at 90°, 5 mm from end to form stop.

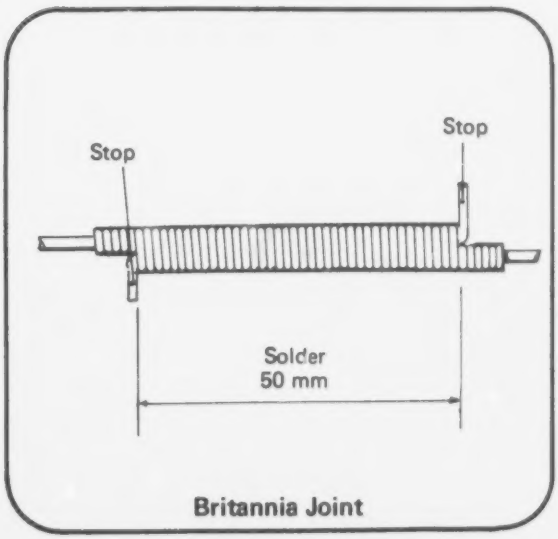
4. Lay wires parallel to each other over a distance of 50 mm with stops in opposite directions.

5. Hold wires in vice.

6. Bind ends together with tinned copper binding wire, carrying the binding past each stop for a few turns.

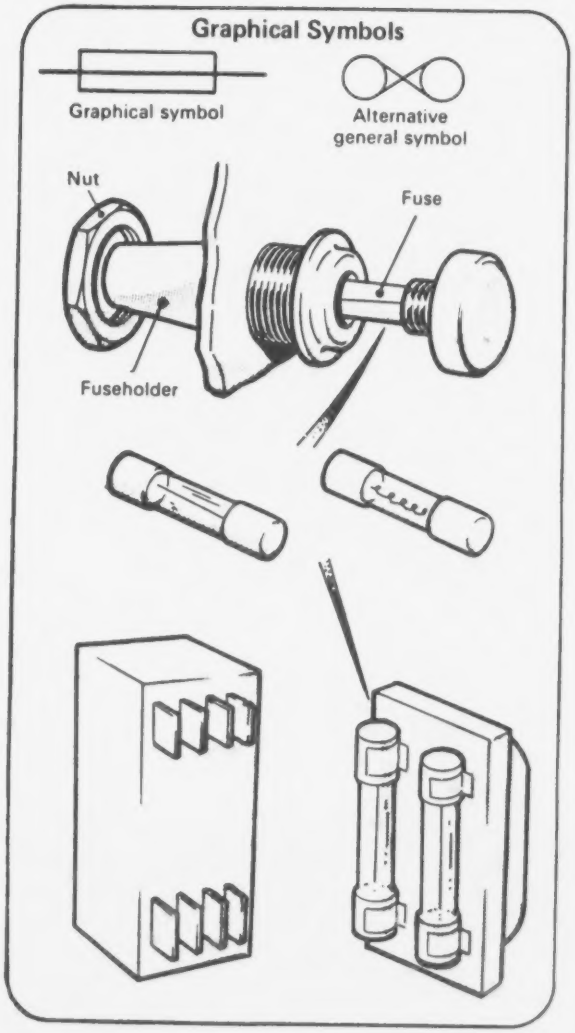
7. Trim ends.

8. Solder joint.

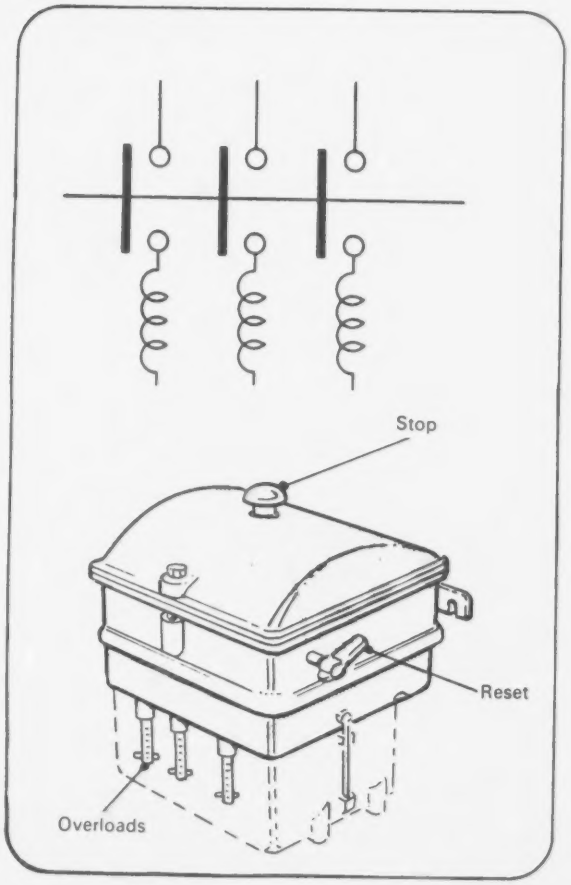


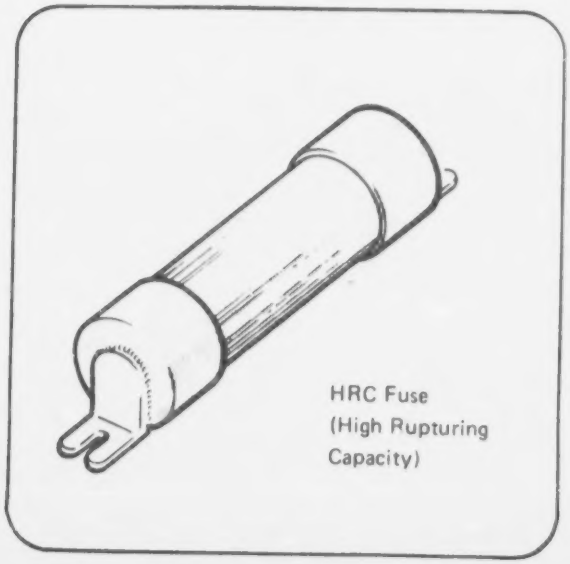
Britannia Joint

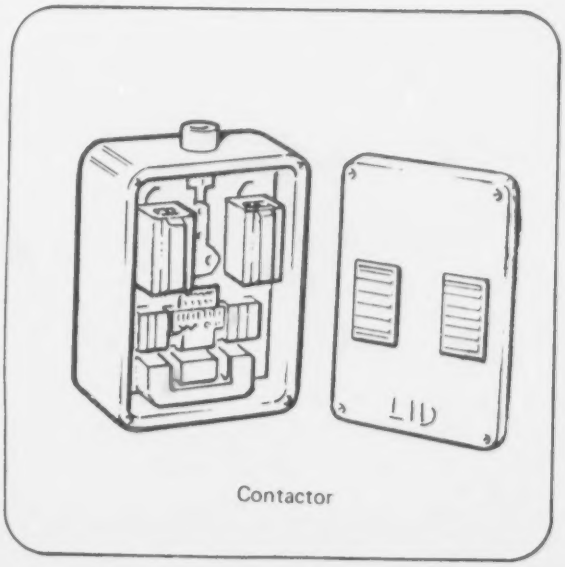
Fuses



Circuit Breakers

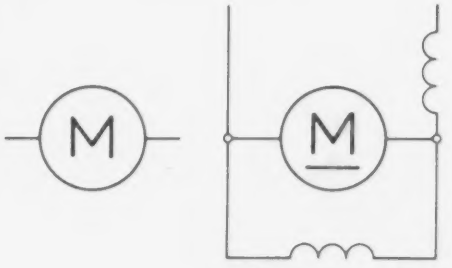




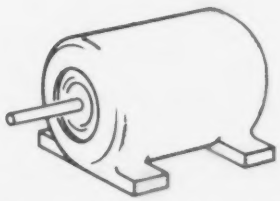


Electric Motors

Graphical Symbols



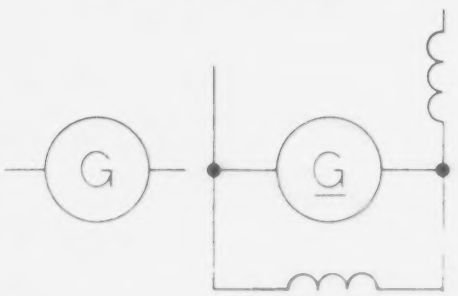
Typical motor (D.C.)



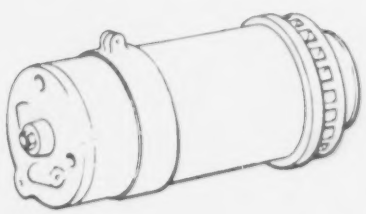
Flange mounted F.H.P.-motor

Generators

Graphical Symbols

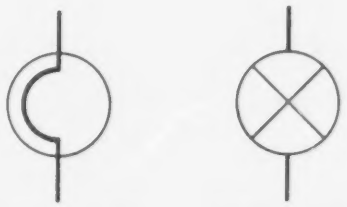


Typical generator

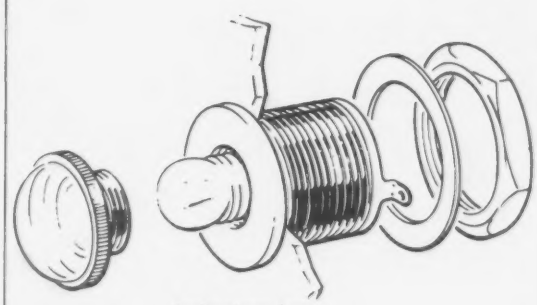


Lamps

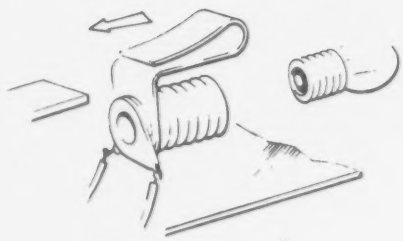
Graphical Symbols



Illuminating lamp Indicating lamp



Indicating lamp



Illuminating lamp

Other Components

Some components are common to both electrical and electronic work and are illustrated on pages 77–80.

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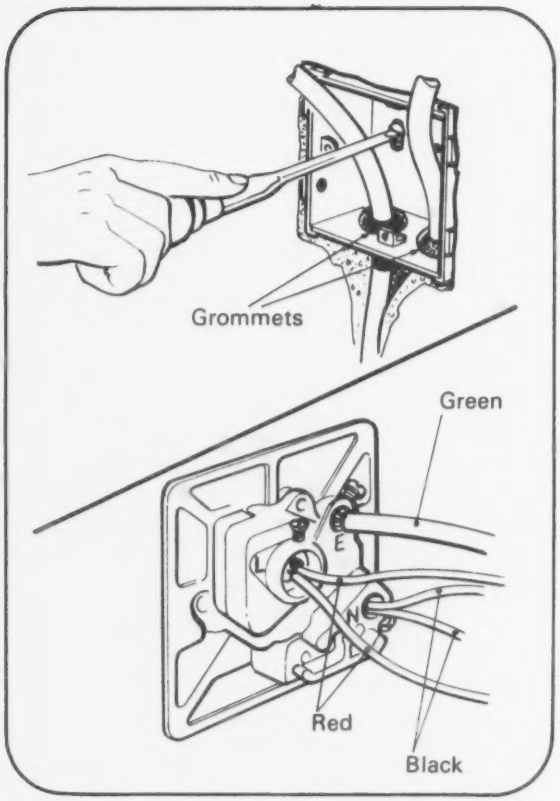


Wiring a socket outlet

(a) Cut the cable loop to make two tails 75 mm long and thread the cables through grommets in the mounting box.

(b) Screw the mounting box to the wall and strip back the cable insulation.

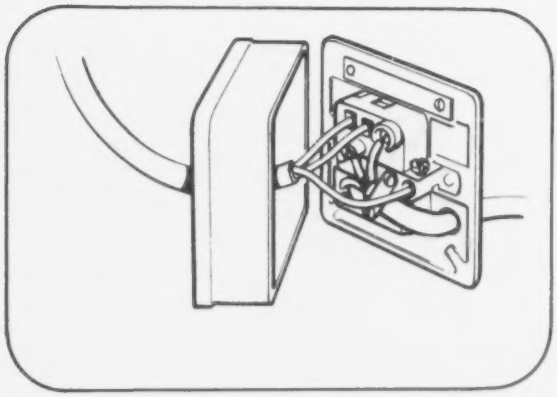
(c) Twist together and connect:
(i) Red wires to terminal L.
(ii)Black wires to terminal N.

(d) Fit green insulated sleeving over both earth wires.

(e) Twist earth wires together and connect to terminal E.

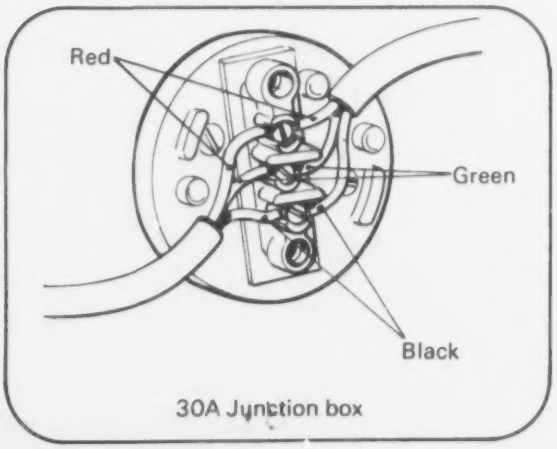
(f) Tighten all securing screws.

Note: Ensure that the wires are pushed into terminals up to the insulation.



Spur boxes

These are fitted in a similar manner to socket outlets but have two sets of terminals. The lead to the appliance must be clamped in the cord grip.



30A Junction box

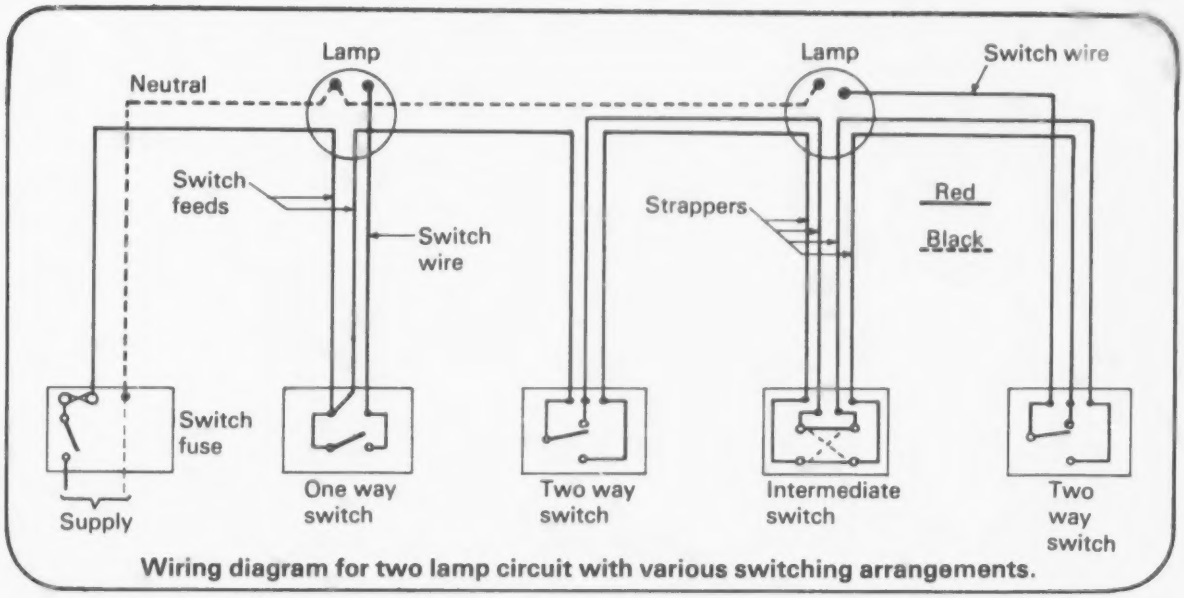
Junction boxes

Junction boxes have four knockout sections for cable entry and exit.

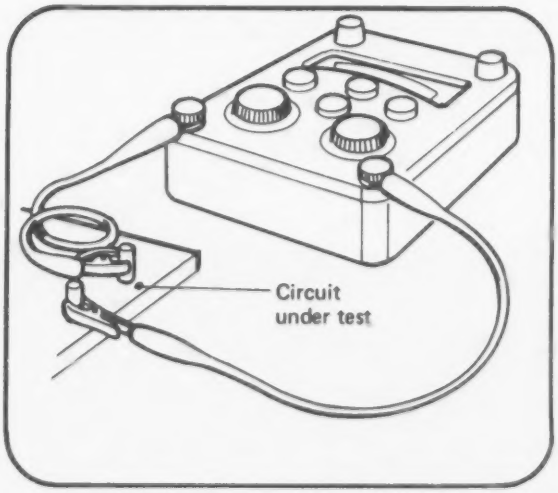
The central terminal is always used for the earth connection.

It is good practice to run spurs from the back of a socket but junction boxes can be used for this purpose.

Keep the number of junction boxes to a minimum.



Wiring diagram for two lamp circuit with various switching arrangements.



To Test for Continuity

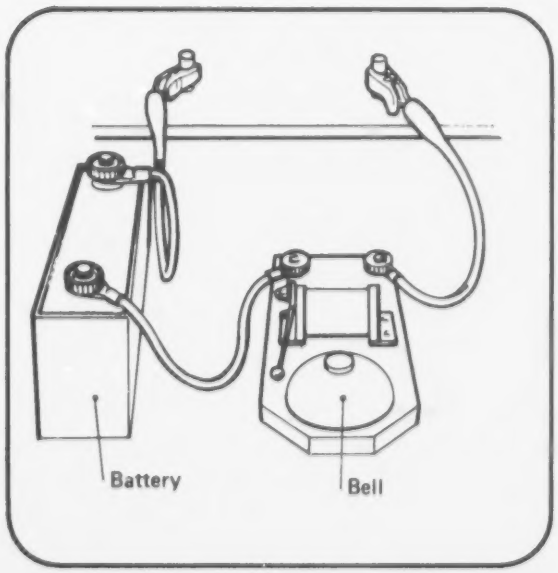
1. Disconnect from all sources of supply.

2. Connect an OHMMETER or CONTINUITY TESTER across the circuit to be checked.

The instrument is calibrated in ohms.

The meter will record a full scale deflection of the needle if the circuit is continuous. With a broken circuit there will be a zero reading.

3. Earthing tests: an ohmmeter test will indicate continuity of conductor between earth pin of plug and body of equipment, but it will not show ability to pass fault currents.



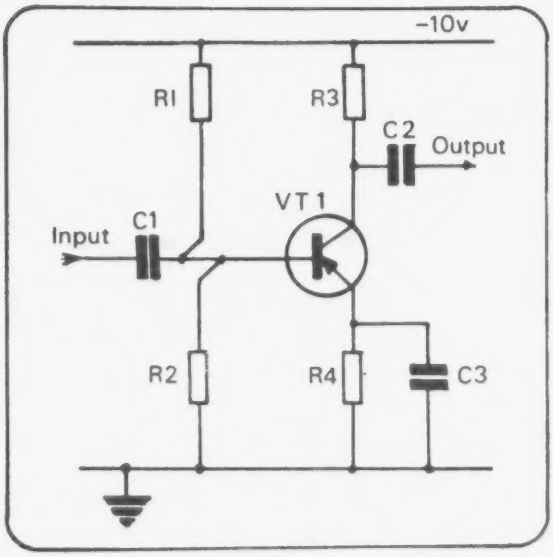
Ringing through – a simple continuity test.

Using a battery and bell in series with the circuit to be tested; the bell rings if the circuit is continuous.

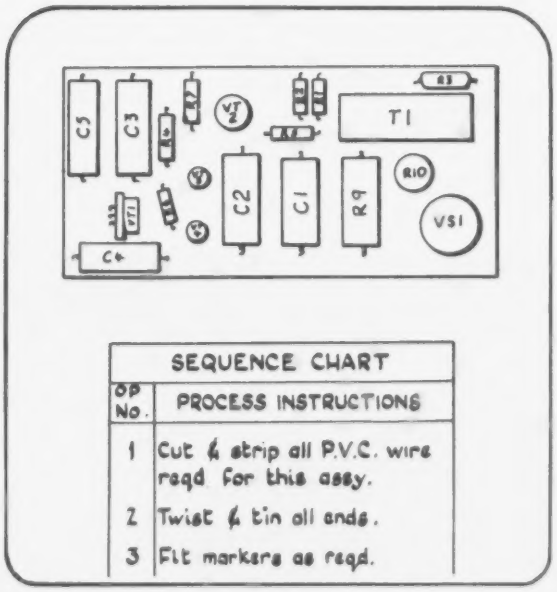
The bell will not ring if the circuit is broken or has a high resistance.

Safety

This method should only be used to test wiring, as many components could be damaged beyond repair by the test current. Check with your instructor that this method is suitable for the circuit to be tested.



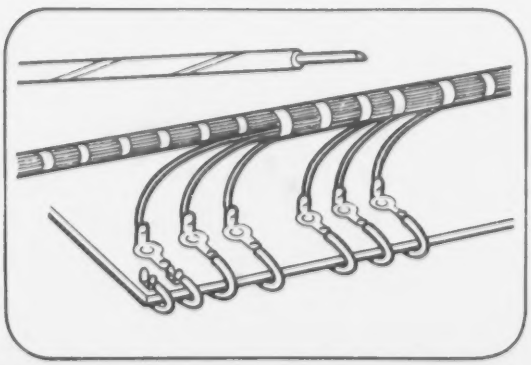
Electronic circuit diagram
A circuit diagram shows by symbols the parts of a circuit and their interconnections. It shows the operation of the circuit but not the physical positions of the parts.



A component layout indicates the positions of components.

SEQUENCE CHART	
OP No.	PROCESS INSTRUCTIONS
1	Cut & strip all P.V.C. wire reqd for this assy.
2	Twist & tin all ends.
3	Fit markers as reqd.

A sequence chart indicates the order in which a series of operations takes place.



Wires and cables
A selection of wires and cables used in electrical and electronic work is shown on pages 62 to 64.

Plastic covered wire
Single tinned copper wire, about 22 s.w.g., insulated with various plastics, is widely used for interconnections between components.
The insulation can be one of a number of basic colours, or a basic colour with a spiral stripe in a different colour.
Wire with the same colour insulation should be used, as this aids the tracing of circuits when fault finding.

Resistors

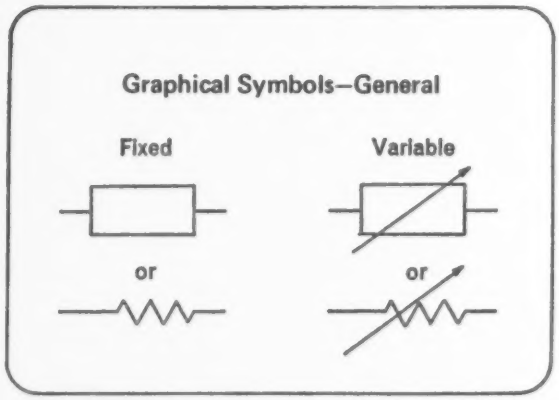
Unit of resistance – ohm (Ω)
1 KILOHM (kΩ) = 1,000 ohms
1 MEGOHM (MΩ) = 1,000,000 ohms

Types – fixed and variable.

Before wiring into circuit check:
1. Resistance in ohms (Ω)

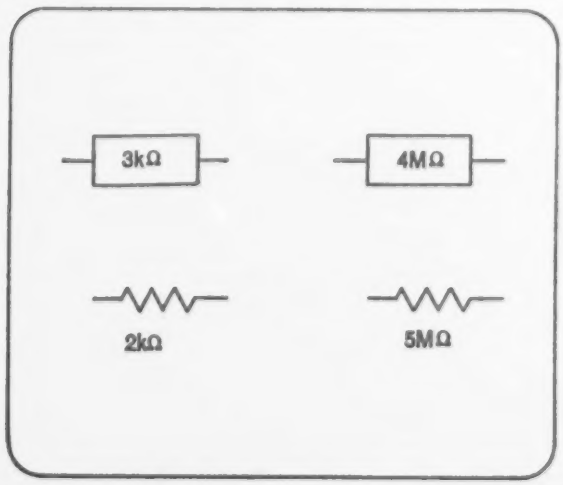
2. Tolerance as a percentage (%).

3. Power rating in watts (W).



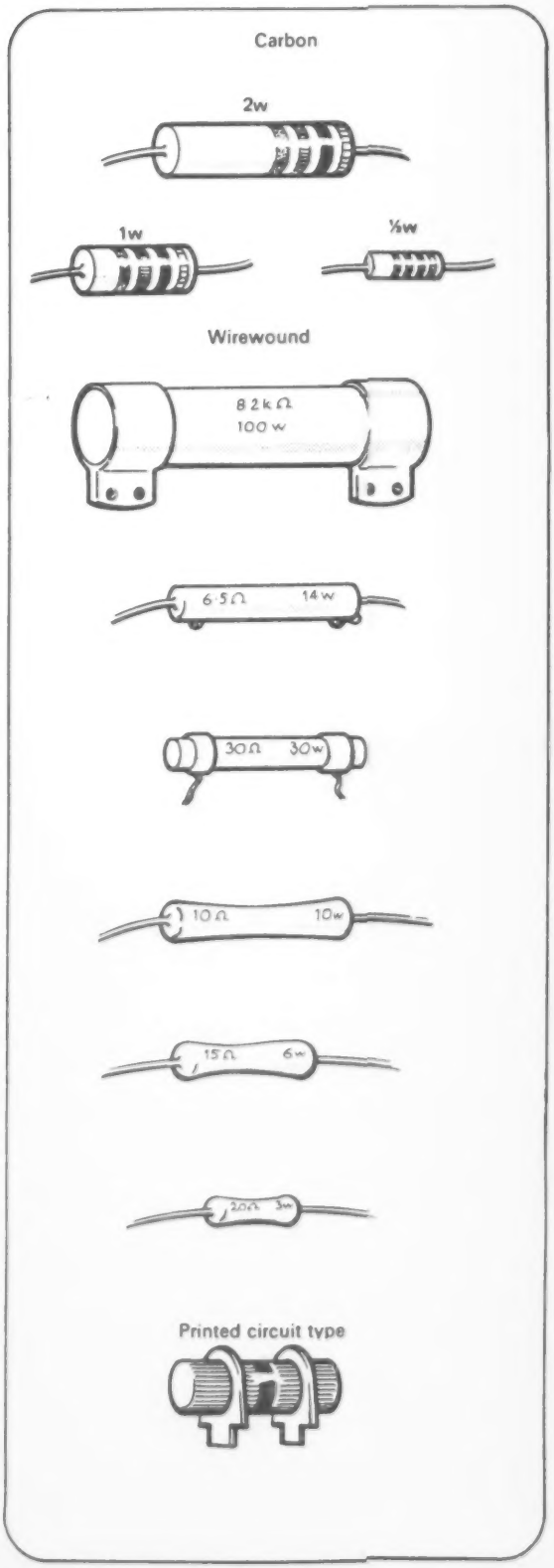
Resistance values

On the circuit diagram the resistance value is shown either on the resistance symbol or close to it.



Fixed resistors

Types – Carbon and wire wound (w.w.).

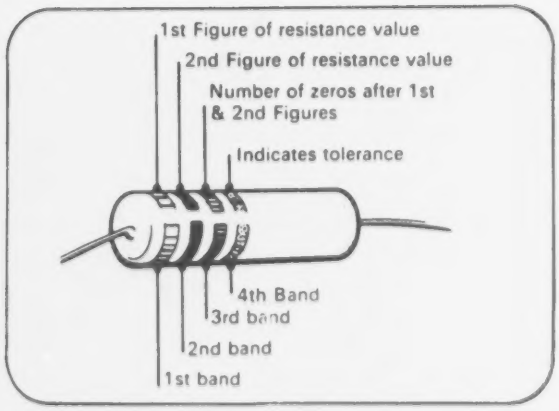


Colour Coding

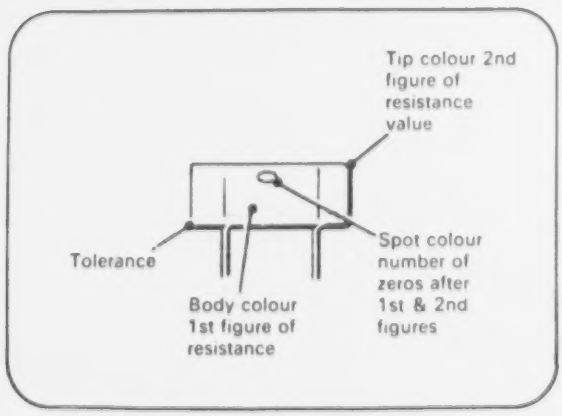
Purpose
To indicate the value and tolerence of carbon composition resistors.

Principles of application
Every colour represents a figure and the position of the colour indicates how the figure should be used.

Colour		Figure		Tolerance
Black	=	0		
Brown	=	1	or	± 1%
Red	=	2	or	± 2%
Orange	=	3	or	± 3%
Yellow	=	4	or	± 4%
Green	=	5		
Blue	=	6		
Violet	=	7		
Grey	=	8		
White	=	9		
Gold	=	Multiplying factor x0.1 or ± 5%		
Silver	=	Multiplying factor x0.01 or ± 10%		
No colour	=			± 20%



Colour bands
Colour bands are one method of using the colour code.


Tip colour 2nd figure of resistance value
Tolerance
Spot colour number of zeros after 1st & 2nd figures
Body colour 1st figure of resistance

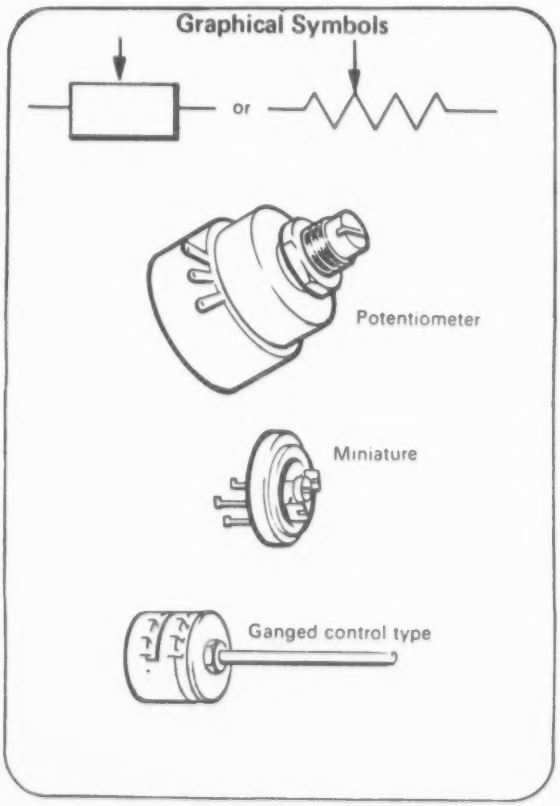
Body, tip and spot colour
An alternative method to the colour bands.

Variable resistors

Potentiometer

A potentiometer is a variable resistor with three terminal connections.

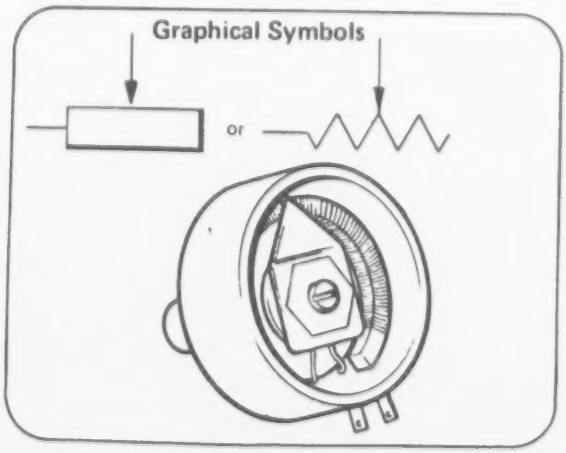
Types – carbon and wire wound.



Rheostat

A rheostat is a variable resistor that has only two terminal connections.

Types – carbon and wire wound.



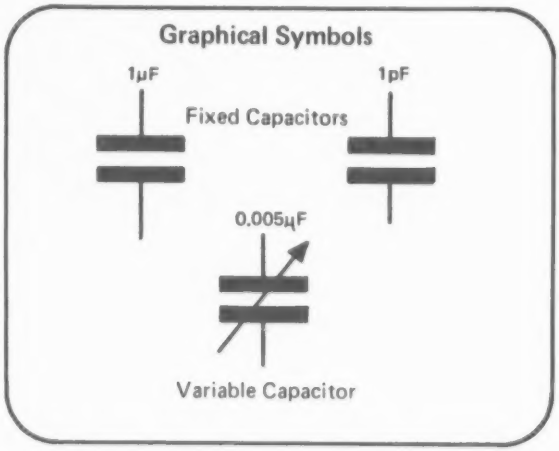
Capacitors

Unit of capacitance – farad (F)
1 Microfarad (μF) = 1 millionth of a farad
1 Picofarad (pF) = 1 millionth of a micro-farad.

Types – fixed and variable.

Before wiring into circuit check:
1. Capacitance in microfarads (μF) or pico-farads (pF).

2. Working voltage in volts (V).

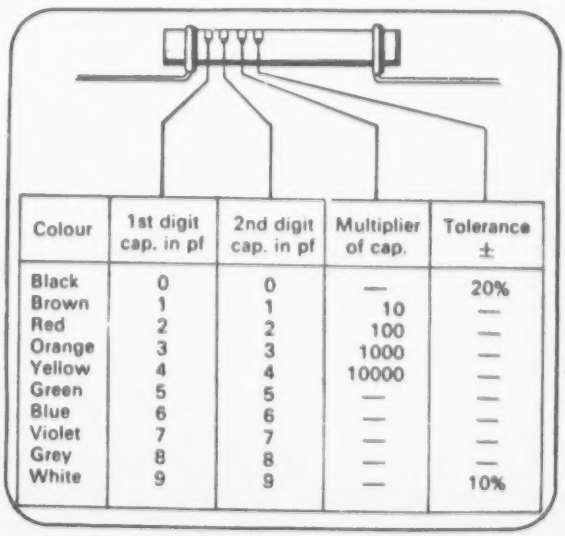


Capacitance values

On the circuit diagram the capacitance value is shown close to the capacitor symbol.

Colour coding

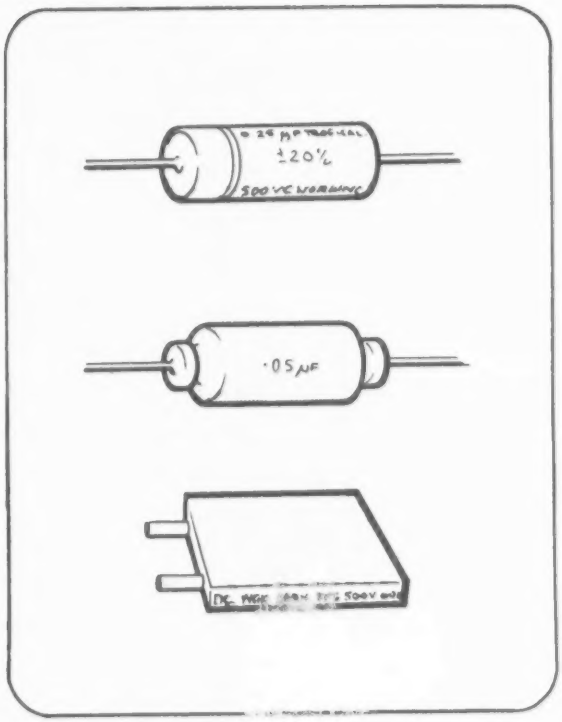
Certain types of capacitor are identified by colour coding.
The simplest coding is the 4-dot code.



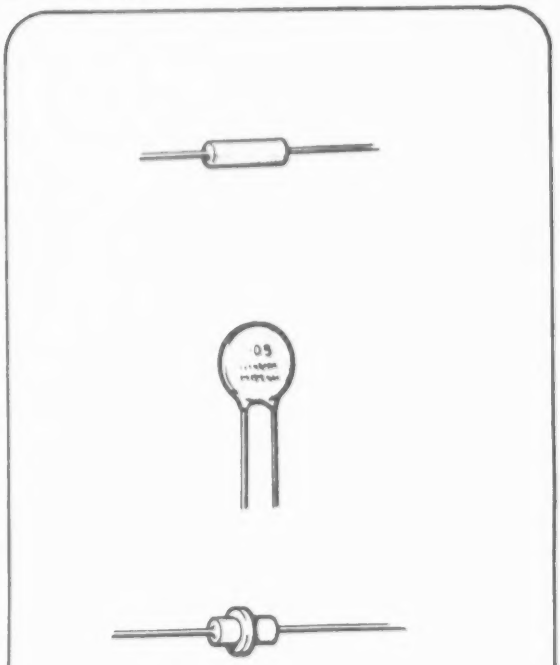
Colour	1st digit cap. in pf	2nd digit cap. in pf	Multiplier of cap.	Tolerance ±
Black	0	0	—	20%
Brown	1	1	10	—
Red	2	2	100	—
Orange	3	3	1000	—
Yellow	4	4	10000	—
Green	5	5	—	—
Blue	6	6	—	—
Violet	7	7	—	—
Grey	8	8	—	—
White	9	9	—	10%

Fixed capacitors

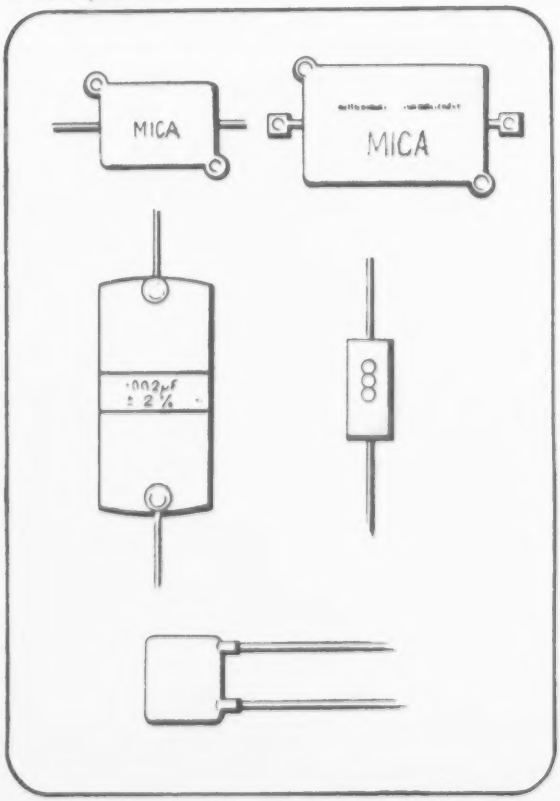
Paper capacitors



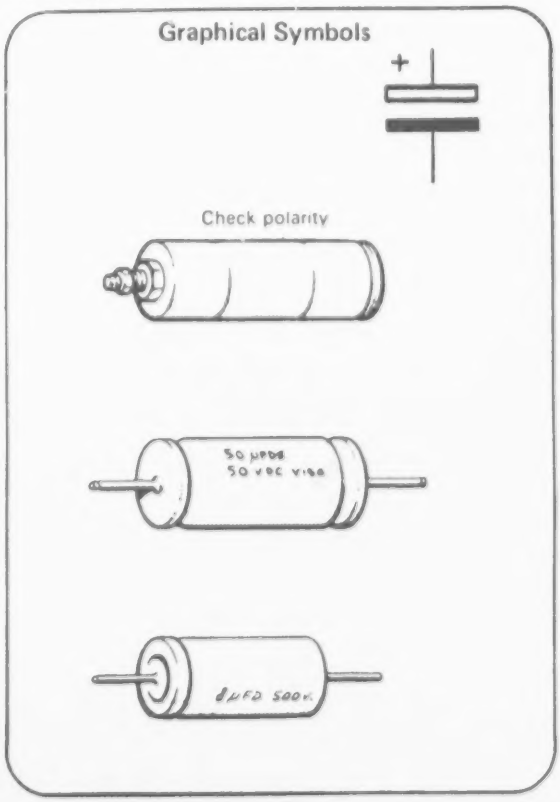
Ceramic capacitors



Mica capacitors

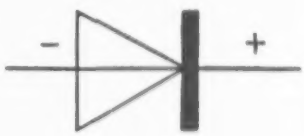


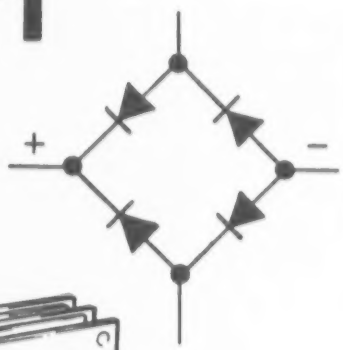
Electrolytic capacitors



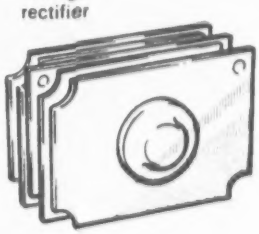
Semi-conductor Diodes

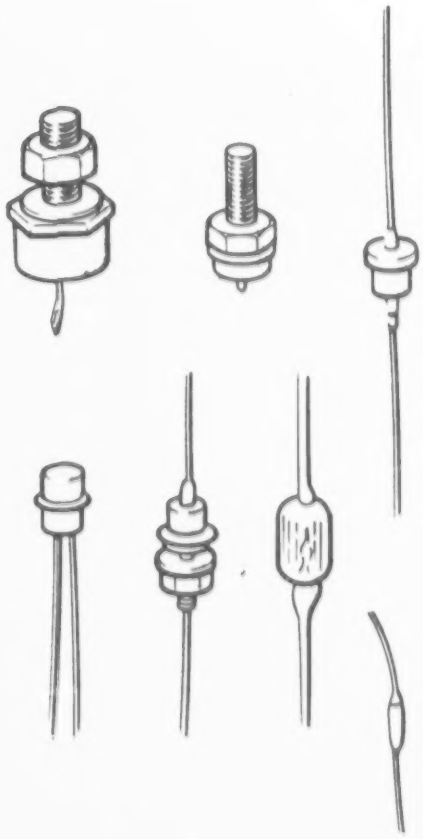
Graphical Symbols





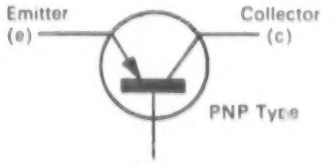
Bridge rectifier

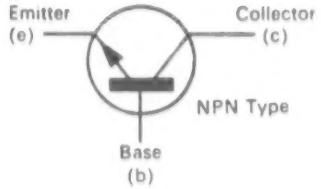


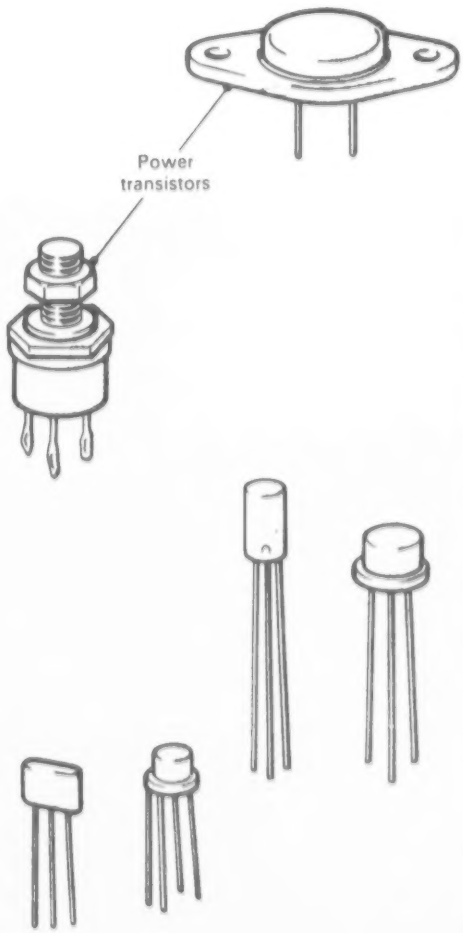


Transistors

Graphical Symbols



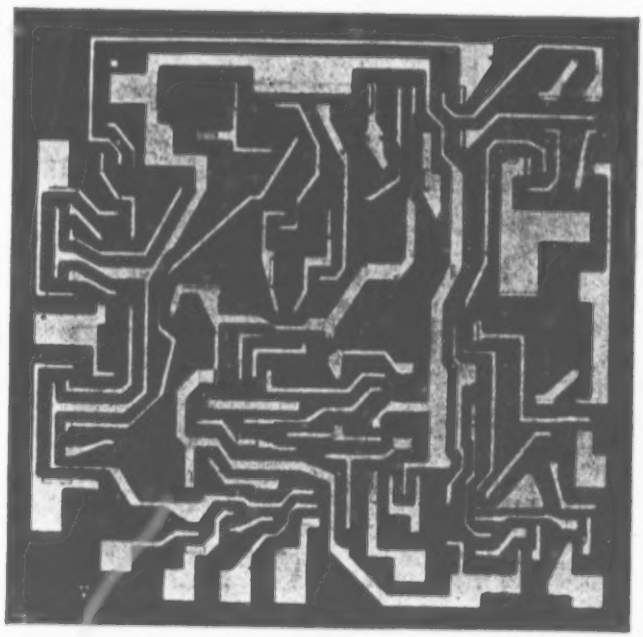




Silicon Integrated Circuits (S.I.C.s)

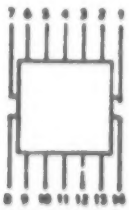
A complete electronic circuit containing transistors, diodes, resistors and capacitors, with all the interconnections can be manufactured by a special technique onto a silicon chip of about 1 or 2 millimetres square. The example below shows a circuit containing 34 transistors.

A highly magnified picture of the silicon chip embodying the above circuit function.

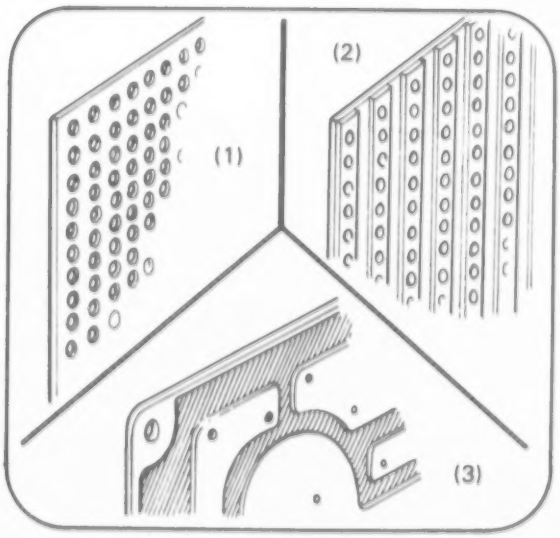


Actual chip size 1 mm. ▪

The chip is mounted in a case, in this example, in a FLAT PACK.

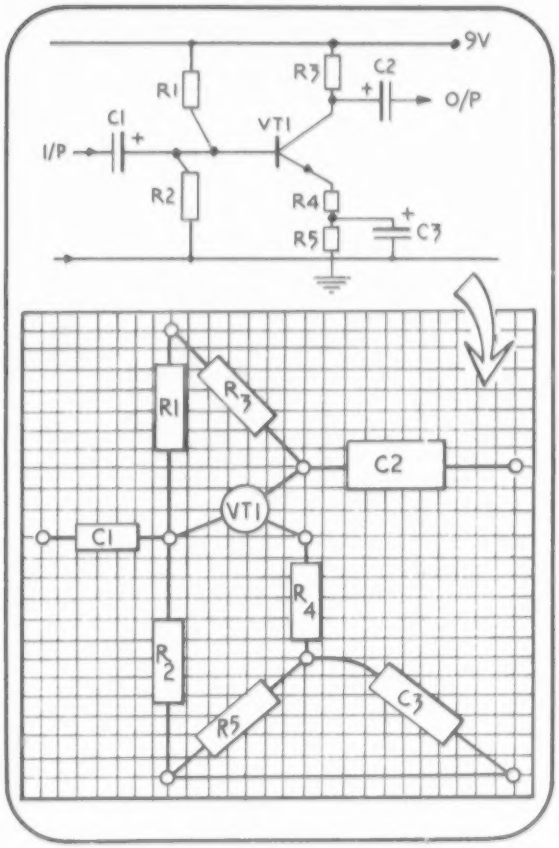


Completed S.I.C.



Types of circuit board

1. Matrix board.
2. Strip board.
3. Copper clad printed circuit board.

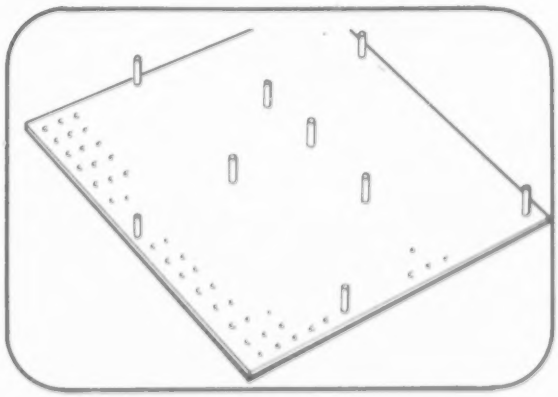


Matrix boards
Used in design and development of circuits. Since components are laid out in the same way as the circuit diagram it is a simple matter to trace components and alterations can be easily made.

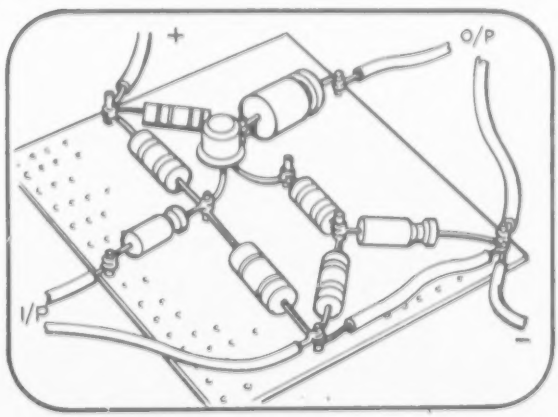
Method of construction

1. Draw a grid on a piece of paper. The distance between the line intersections should be the same as the distance between holes on the matrix board.

2. Draw the components to scale on to the grid, marking the positions of any terminal pins. The appearance of the drawing should be similar to the circuit diagram.

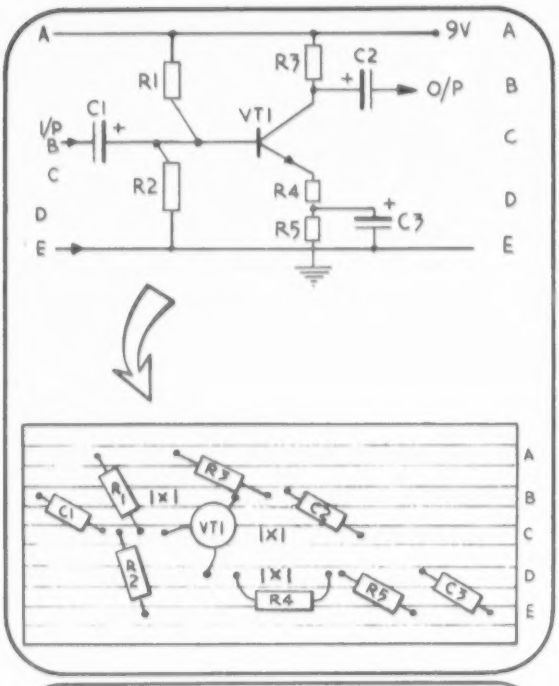


3. Insert pin tags into identified holes on matrix board.



4. Assemble and solder components to pin tags.

5. Connect leads to appropriate tags.



Strip boards
Used in design and development of circuits. This method allows design alterations to be incorporated readily.

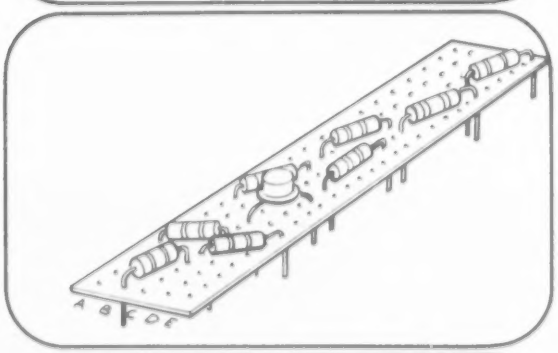
Method of construction
1. Letter each horizontal link.
Note: Sometimes it is possible to letter two horizontal links by the same letter.

2. Shade alternate rows on lined paper to represent the number of horizontal links already determined.

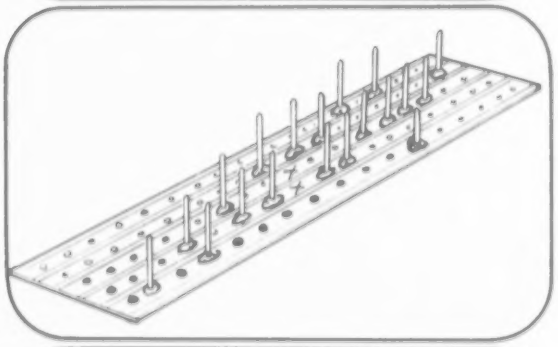
3. Draw onto the paper the components in the approximate positions they will take up on the finished strip board.

4. Mark any necessary breaks in copper tracks.

5. Insert components into strip board working to the prepared drawing.



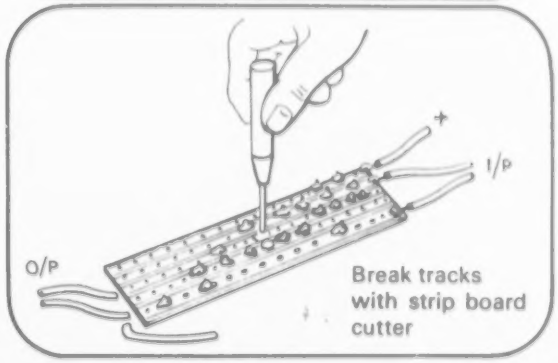
6. Invert strip board and solder component connections to appropriate copper tracks.

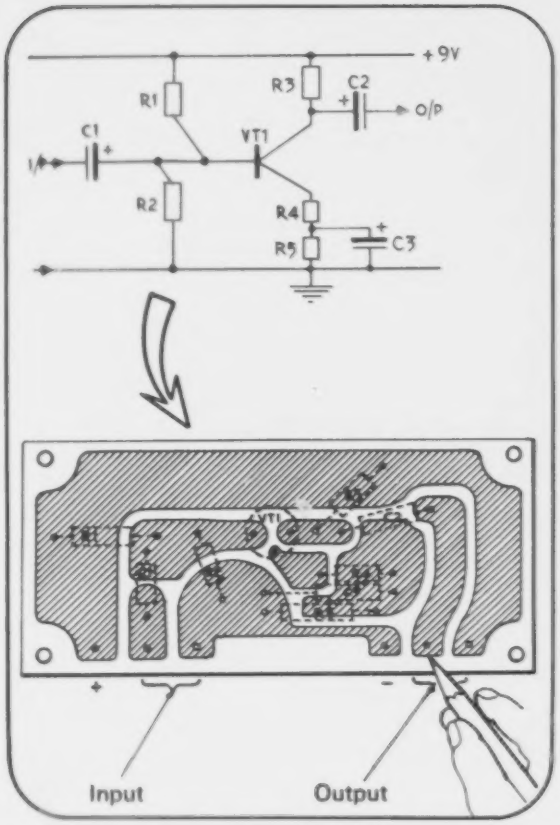


7. Trim component connections.

8. Break copper tracks as required using a strip board cutter.

9. Connect leads to appropriate copper tracks.



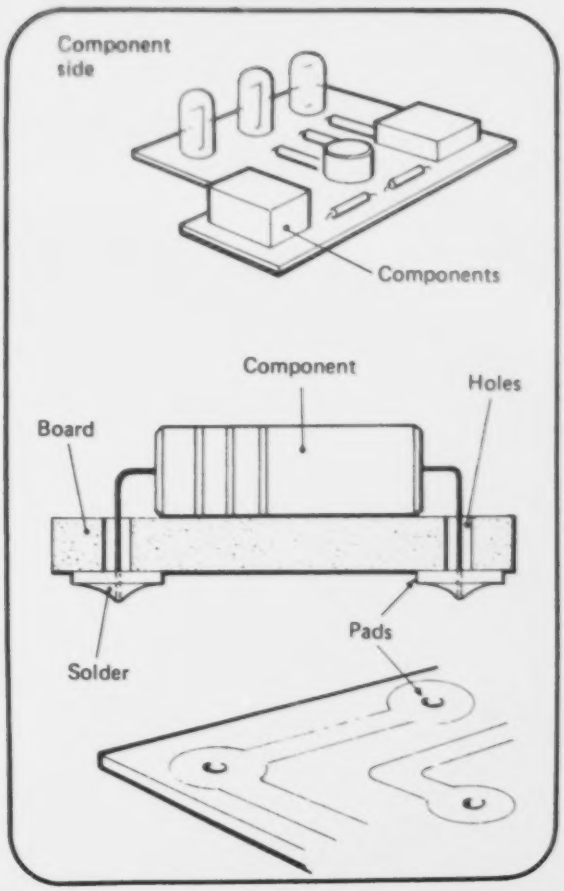


Printed circuit boards

When a circuit has been finally proved it may be converted into a printed circuit which can be manufactured in quantity.

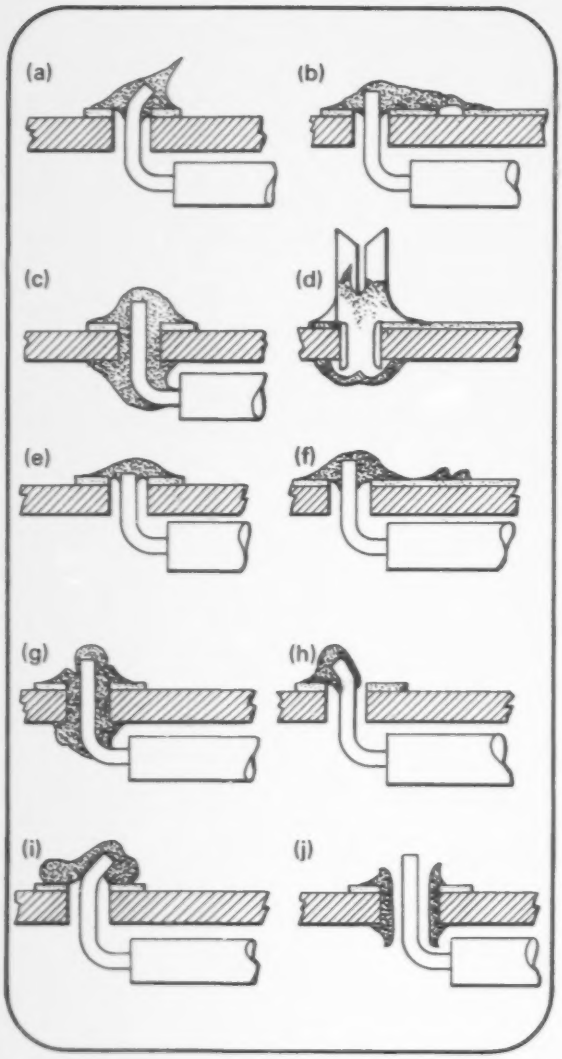
A printed circuit board consists of a metallic foil pattern attached to the surface of an insulator board. The metallic foil is used to make interconnections between the electronic components and thus forms the circuit.

The pattern is called the track.
The connecting points of the track are called pads.



The components are mounted on the opposite side of the board to the track.

Component wires pass through holes in the board and are soldered to the track pads.



Printed circuit board soldering faults

(a) Spiking

(b) Excess solder bridging across track or pads causing short circuit

(c) Excess solder

(d) Excess flow down contact

(e) Excess solder, outline of lead not visible through solder

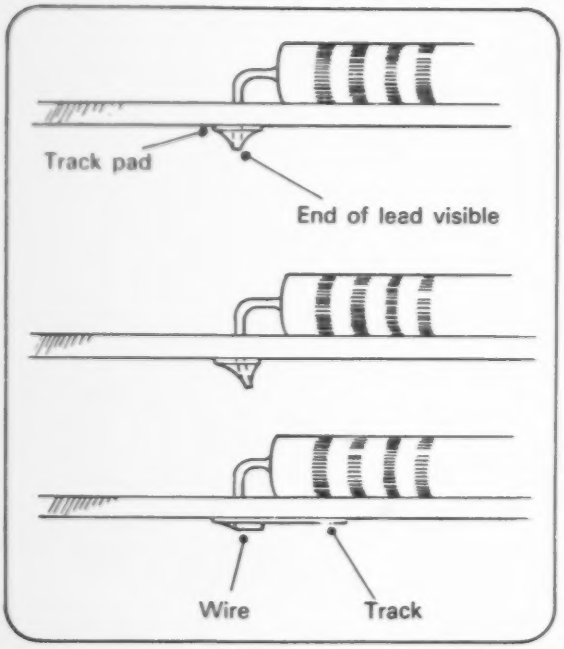
(f) Excess solder, build up on tracks and areas without holes

(g) Ring of dirt round lead and dull appearance of solder, possible blow hole

(h) Insufficient solder

(i) Poor solder flow, appears dull and blobby

(j) Dry joint, possible dirty lead.



Good joints

Typical joints are shown. The end of the lead should be visible through the solder and the surface of the solder should be concave.

1. The end of the lead is at right angles to the board.

2. The end of the lead is at an angle of less than 30° from the vertical.

3. The end of the lead is bent parallel to the board. Bend the lead in the direction of the track.

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E I T B **Foundation Training**

OFF-THE-JOB WORK RECORD BOOK

NAME _____

DATE _____

UNIT Nos. _____

ENGINEERING INDUSTRY TRAINING BOARD **YT 16**

© ENGINEERING INDUSTRY TRAINING BOARD 1983

Page 196

is a sample page

from this work record.

Printed in England by Hills & Lacy Ltd, Reading and London 28073

DESCRIPTION OF JOB		Date:
		Job No.:

Instructor's Comment

E I T B **Foundation Training**

WORK EXPERIENCE GUIDE AND LOG BOOK

TRAINEE'S NAME _____

ENGINEERING INDUSTRY TRAINING BOARD **YT 17**

ACKNOWLEDGEMENTS

This booklet has been developed from the Engineering Work Experience Guide published by the Engineering Careers Information Service (ECIS).

The ECIS guide was based on the work experience booklet produced by the Clydebank EEC Pilot Project for Strathclyde Department of Education.

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INTRODUCTION

What is work experience all about?

Work experience is a unique opportunity for you to explore the world of work. You can:

* find out about the significance of work
* discover something about your own skills, preferences and talents
* investigate how you can develop your potential through job choice and vocational training
* begin to adjust to the changed environment, routine and standards expected at work.

You will be treated during your work experience like junior employees. You will undertake normal duties and, by mutual agreement, work normal working hours. You will be expected to help, to the best of your ability, in the daily work under the supervision of older or more senior employees. You will need to take note of and obey health and safety regulations and co-operate with all members of the company's staff. You should wear suitable clothing.

The coloured pages of this book provide information on preparation you should do before starting your work experience programme, some follow-up suggestions, and information relating to securing a job. There is information which emphasises job seeking skills and also some practical guidance on 'selling' yourself.

The white pages of the book are provided for use as a diary, recording your experience. This will help you organise your thoughts and no doubt prove useful to show a future employer what you did during your work experience programme. If you expect to get work experience in more than one company you might make more than one entry under some of the headings.

WORK DIARY. In this section, write a very brief description of each type of job you do, including the date/s on which each job was done. Fill in the diary as soon as you can and ask your job supervisor to confirm the entry with a signature.

LOG BOOK. This contains various tasks to be performed and may be more difficult to fill in because it is up to you to find out much of the information. Use any style of entry you think suitable, for example, sketches, write-ups, photographs and company forms might all be used. By completing the suggested tasks you will learn a great deal about the work in a short time and get more benefit from your programme. When you think you have sufficient information to complete a task talk it over with your supervisor to check the facts. The tasks can be done in any order. Aim to try and do one each week.

WORK EXPERIENCE AND YOU

This booklet has been written to help you get the best out of your work experience.

What will it be like? What can I get out of it? What will I have to put into it? What do you want to find out?

Write down your thoughts, the questions you'd like to ask, what you are hoping for.

YOUR PERSONAL CHECKLIST

Company name.....

Address.....

.....

..... Tel. No. .....

Report to Mr/Mrs/Miss.....

Department.....

Time and date.....

Travel arrangements

Leave home at.....

Bus/train time and fare.....

Suitable clothing.....

Eating arrangements.....

YOUR PERSONAL CHECKLIST

Company name.....

Address.....

.....

..... Tel. No. .....

Report to Mr/Mrs/Miss.....

Department.....

Time and date.....

Travel arrangements

Leave home at.....

Bus/train time and fare.....

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Address.....

.....

..... Tel. No. .....

Report to Mr/Mrs/Miss.....

Department.....

Time and date.....

Travel arrangements

Leave home at.....

Bus/train time and fare.....

Suitable clothing.....

Eating arrangements.....

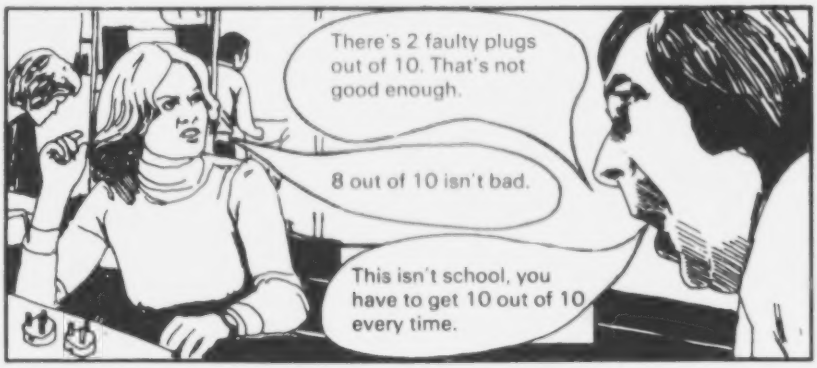
WHAT IS WORK REALLY LIKE?

Work is very different from school or being unemployed. You'll be with different people who want different things from you.

Here are some of the things that may happen at work:

Things are different at work.
Julie was on an assembly line. She thought she'd done a good job.

At work the things you make are important. They affect other people; no one wants to buy a faulty plug. That's why quality counts.


There's 2 faulty plugs out of 10. That's not good enough.
8 out of 10 isn't bad.
This isn't school, you have to get 10 out of 10 every time.

What does the boss mean?
ASK if you're not sure what the boss means or you might make an expensive mistake.

Putting your foot in it.
It's not always obvious what you're expected to do or say.

You'll have to find out the hard way. Everyone does!

Work's different because

- ★ Time is money
- ★ What you produce is valuable
- ★ Other people depend on you
- ★ You'll have to work on your own and be part of a team.

so

- ★ Have a sense of humour
- ★ If you have a problem, ask someone. Don't just walk out.

This page is reproduced from the BBC Roadshow booklet.

Make sure this is completed for each job you do.
Ask whoever is supervising you at work (the foreman, for example) to sign it at the end of each entry.

Dates	Work Done or Observed	Supervisor and Department
16-11-82	EXAMPLE Mr. Brown showed me how to use a pillar drill to make holes 6mm. dia. in some end plates using a special jig to get them in the right place. He also showed me how to use a plug gauge to check the size. One of the holes had to be tapped.	Mr. Brown. Fabrication Shop. P. Brown 18/11
18-11-82	I completed a batch of 85 end plates.	

WORK DIARY

Dates	Work Done or Observed	Supervisor and Department

LOG BOOK

TASK: YOUR EXPERIENCE PROGRAMME

Write down where you will be working during your work experience programme and also, if possible, what work you might be doing. Find out who are responsible for checking this log book and when you must show it them.

EXAMPLE

Mrs. Donovan to see log book every Monday afternoon.

Receipt and dispatch. 2 weeks. Loading and unloading vehicles.

First op. shop. 3 weeks

General assistant to setter/operator.

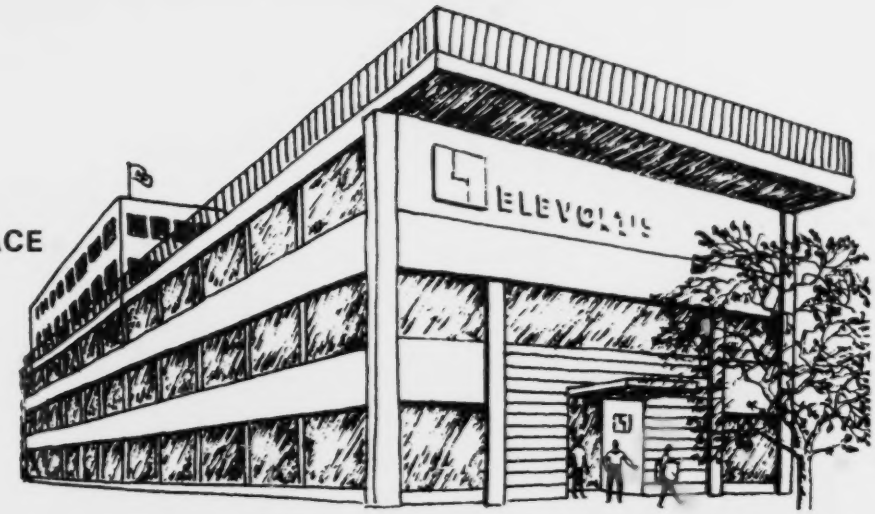
Second op. shop. 3 weeks. Helping . . .

TASK: KEEPING WITHIN THE RULES

There are many rules in a company both written and unwritten. Nobody will expect you to know them all at first but you should get to know the important ones as quickly as possible. For example, you may not know the answers to these questions: Do you have to ask permission to leave your place of work? Can you go in the canteen in overalls? What are the safety regulations in the paint shop? Write down some of the questions you would like answered and discuss them with someone who can give you the correct information.

LOG BOOK

TASK:
YOUR WORKPLACE



Use the following pages to draw or make sketches of the layout of the departments you work in during the programme. Mark on the positions and names of pieces of equipment or machinery and give approximate dimensions of each area. Write a description of the workplaces so that other people can get some idea of what it was like to work in each area.

LOG BOOK

TASK: EQUIPMENT AND TOOLS

On the following pages give some examples of machinery, industrial plant, tools or instruments used at your work. Draw a sketch or diagram of them, label the parts. Explain what they are, what they do, and how they are used.

TASK: DIFFERENT JOBS

Take note of the different jobs you see going on around you, which of the jobs listed below are carried out in the company?

Accountant	
Assembler	
Automatic Machine Minder	
Buyer (raw materials and parts)	
Computer Programmer	
Copy/Audio Typist	
Cost Control Clerk	
Customer Service Clerk	
Design Engineer	
Draughtsman/woman	
Development Engineer	
Estimator	
Export Clerk	
Field Sales Representative	
Industrial Relations Officer	
Inspector	
Invoice Clerk	
Jig and Tool Designer	
Laboratory Technician	
Lifting Truck Driver	
Mail Clerk	
Maintenance Engineer	
Maintenance Fitter	
Marketing Research Assistant	
Materials Control Clerk	
Methods Study Engineer	
Office Machine Operator	

Order Clerk	
Packer	
Personnel Officer	
Plant Engineer	
Press Operator	
Production Controller	
Progress Clerk	
Quality Control Engineer	
Quality Assurance Engineer	
Receptionist	
Research Engineer	
Sales Engineer	
Secretary	
Security Officer	
Setter Operator	
Stock Controller	
Storekeeper	
Supervisor	
Systems Analyst	
Telephonist	
Test Engineer	
Toolmaker	
Training Officer	
Transport Officer	
Wages Clerk	
Warehouseman	
Works Manager	

Write a brief description of the ones for which you feel you might be suitable.

TASK: COMPANY PRODUCTS OR SERVICES

Write a very brief description of the products or services your company sells. Try to list other companies who do similar things. If the company is a member of a group of companies you might also be able to find out what the other members of the group do.

TASK: COMPANY COSTS

Make a list of all the things which must be paid for to keep the company running.

TASK: THE ORGANISATION

All organisations or firms are made up of individual people.

Draw up an organisation chart or family tree for the firm or department in which you are working.

RECORD OF JOB APPLICATIONS

It is important that you keep a record of all the jobs that you apply for.

By filling in this page it will help you to control an exercise that could become confusing when you are involved in a lot of letter writing.

It will also ensure that you turn up at the right time, at the right place and on the right day for interview.

'Good luck with your applications'.

Date	Employer's name	Address	Replies	
			Received	Interview
(example) 10.1.83	Mr I. Select Personnel Manager ABC Co Ltd	Ajax Works, High Street, Newtown	Yes 21.1.83	09.00 hrs 30.1.83

TASK: HOW DO EMPLOYERS SELECT?

Employers test the suitability of applicants in a number of ways. In one of your work experience companies find out if the employer:

- ★ asks for information about your school performance
- ★ gives a selection test
- ★ asks applicants to come for an interview.

What kind of person is the employer looking for?

Employers are not interested in applicants who will not do a good job. No one is going to pay you if your work is a waste of money.

Number these from 1 to 10 in their order of importance, when being considered for a job by this employer.

- ☐ keenness to work
- ☐ keenness to train
- ☐ skills
- ☐ honesty
- ☐ personality
- ☐ ability to get on with the public
- ☐ ability to get on with workmates
- ☐ education, qualifications
- ☐ experience
- ☐ personal appearance, voice, manner

Would these spoil your chances?

ARE APPLICANTS REJECTED FOR THESE REASONS		Turned down often	some-times	not often
SCHOOL PERFORMANCE	Poor reading, writing and spelling	☐	☐	☐
	Poor arithmetic	☐	☐	☐
	No exam passes	☐	☐	☐
	Too few exam passes	☐	☐	☐
	Bad behaviour	☐	☐	☐
	Truancy	☐	☐	☐
	Police record	☐	☐	☐
EMPLOYERS SELECTION TEST	Poor reading and writing	☐	☐	☐
	Poor arithmetic	☐	☐	☐
	Poor mathematics	☐	☐	☐
PERFORMANCE AT INTERVIEW	Lateness for interview	☐	☐	☐
	Lack of interest in the work	☐	☐	☐
	Lack of interest in training	☐	☐	☐
	Dirty/untidy hair, clothes or shoes	☐	☐	☐
	Informal clothing (jeans, no tie, etc.)	☐	☐	☐
	Lack of politeness	☐	☐	☐
	One word answers	☐	☐	☐
	Mumbling	☐	☐	☐
	Fidgeting, slouching	☐	☐	☐
	Smoking during interview	☐	☐	☐

TASK: MAKING THE BEST OF JOB OPPORTUNITIES

What age will you be at the end of this programme?

What jobs/training does this firm offer to young people at this age?

Choose one of these jobs. Write down the sort of things a school leaver would find helpful in doing that job under the following headings.

		How do you match up? well	badly
Practical skills	1	☐	☐
	2	☐	☐
	3	☐	☐
	4	☐	☐
Examination subjects	1	☐	☐
	2	☐	☐
	3	☐	☐
	4	☐	☐
Personal qualities	1	☐	☐
	2	☐	☐
	3	☐	☐
	4	☐	☐

MAKING A GOOD FIRST IMPRESSION

There are far more applicants than there are vacancies. So many applicants are turned down. You have to make a good first impression or you will not be considered.

WOULD THESE SPOIL YOUR CHANCES?		often	some-times	not often
APPLICATION FORM	Untidy	☐	☐	☐
	Difficult to read	☐	☐	☐
	Bad spelling	☐	☐	☐
	Incomplete	☐	☐	☐
PHONE CALL	Mumbling	☐	☐	☐
	Wasting time	☐	☐	☐
	Running out of change	☐	☐	☐
	Asking for the wrong department	☐	☐	☐
PERSONAL APPLICATION	Wrong clothes	☐	☐	☐
	Wrong manners	☐	☐	☐

THE GOODWILL OF YOUR 'EMPLOYER'

The EITB was able to arrange a work experience place for you, thanks to the goodwill of a local employer. Why not write to thank him or her?

- ★ Probably a number of people were kind enough to help you. They would appreciate a letter passing on your thanks.
- ★ The EITB may wish to send other people to the same employer next year. Your letter will encourage the employer to accept them.
- ★ It is good practice to learn how to write a business letter, using the correct layout, punctuation and spelling, and neat handwriting.

Here is a letter of thanks from a sixteen year old boy, Ian Lawrence. It may give you ideas about how to write your own letter.

Ian left a good margin on this side, so that Mr Stewart's secretary could file the letter.

Ian wrote his address in the top right-hand corner.

Next comes the date.

14 Longside Drive
Newton G81 1BN
24 April 1983

Mr. W.J. Stewart
Personnel Manager
Turners Enterprises Ltd.
220 High Street
Newton G81 5DW

The letter title (underlined) helps Mr Stewart's secretary.

Ian wrote the name, title and address of the person he was writing to here.

Ian had met Mr Stewart so he used his name.

Dear Mr. Stewart,

Work Experience 31 January - 22 April 1983

Thank you for letting me spend my Work Experience at Turners. I found it interesting, especially the time I spent in the Welding Shop, and the chance to learn spot welding.

Please will you thank everyone who helped me, especially Mr. Brunton and Jim Anderson.

Yours sincerely
Ian Lawrence

Ian would have ended 'Yours faithfully', if he began 'Dear Sir'.

WHERE TO LOOK FOR JOBS

If you want a job you have to go out and look for it.
It won't come to you.
There are lots of places around where you can find out about jobs.
Have some idea of the kind of job you are looking for, before you set out.

CAREERS SERVICE

When you go to the Careers Office ask if they have any vacancies. They will find out what kind of work you want and help you to get it. If you need training they will help you with that too.

JOB CENTRE

Anyone can go to the Jobcentre or Employment Office. You can look at the cards telling you about some jobs. If you are interested in one, note down the card number and go to the desk.

If you can't see a job you want ask to see an Employment Adviser. They will tell you if there are any other jobs. Don't feel you have to take the first job you're offered. If you don't think you will be happy in a job, SAY SO!

FRIENDS

Tell your mates and relations you are looking for a job. They may hear of something where they work or from someone else. They will also be able to put in a good word for you.

ADVERTS

Look at the adverts in the LOCAL PAPER. Look for jobs in the part called CLASSIFIED ADVERTISEMENTS.

Look under SITUATIONS VACANT.

You will probably have to phone or write a letter for the job you want (see page 50).

NOTICES

Some firms have a notice board outside.

It says what jobs are on offer. It may say VACANCIES at the top of the board. Sometimes jobs are advertised on cards in shop windows, so keep your eyes open for them.

CALLING

This is a good way of looking for jobs but don't be disappointed when people say No!

Go to factories, shops and other employers near you. If they ask you in, be ready to tell them about yourself and what you have to offer.

Even if they haven't got any jobs when you go they will probably remember you when a job does come up.

This page is reproduced from the BBC Roadshow booklet.

USEFUL ADDRESSES

CAREERS SERVICE – go to the Careers Office

Address .....

.....

Careers Officer's name (Mr/Mrs/Miss) .....

JOBCENTRE – anyone can go to the Jobcentre or Employment Office

Address .....

.....

ADVERTS – look at the adverts in the LOCAL PAPER

Names of three local papers:

1. ..... Look at classified ads on page .....
2. ..... Look at classified ads on page .....
3. ..... Look at classified ads on page .....

YELLOW PAGES and LOCAL EMPLOYERS

This is a good way of looking for jobs but don't be disappointed when people say No!

Heading in Yellow Pages (and type of job)	Name and address of possible employer	Telephone No.

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SELLING YOURSELF – LETTERS AND TELEPHONES

It's not always easy to sell yourself to an employer by phone or letter. Here are a few hints:

LETTERS

WANTED
Stores person for car parts firm. Apply in writing to Mr Pike, Arrowparts, Hartlepool.

Mr. Pike
Arrowparts
Hartlepool.

Your address
Date.

Dear Mr. Pike,

I wish to apply for the job of storesperson advertised in today's paper.

I am 17 and left Bideford School in May 1979 with CSE English and Maths.

I have attended Marpool College on a short industrial course, and for the last 6 months I have worked in a warehouse. I am very interested in working for a parts firm. I can come for interview at any time.

Mr. P. Green, Marpool College, will act as referee.

Yours sincerely
Kevin Watt.

Your age
School you went to
The job you want
Training
Work experience
If you started 'Dear Sir' put 'Yours faithfully' on the end

'I think I'll call this one for an interview'.

I'm looking for:

- ★ Neat handwriting
- ★ Proper layout
- ★ That my name *and* the firm's is spelt properly
- ★ A letter that's short and to the point.

TELEPHONES

WANTED
School leavers for packing work. Phone Cardiff 3629, ask for Mrs White, ext. 25.

Hello, can I speak to Mrs White please, extension 25?
Hello, Mrs White speaking, can I help you?
It's about the job as packer in today's paper. I'm 16 and I've just left school.
Can I have your name and address please? Can you come for an interview on Tuesday at 10 am?

When you make a call to a firm you must . . .

- ★ Have lots of 5p or 10p pieces
- ★ Have the number you're phoning
- ★ Have the extension number if there is one
- ★ Have the name of the person you're phoning if you know it
- ★ Have the *reason* – to ask for a form? make an appointment? ask if there's a job?
- ★ Have a pencil and paper ready.

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SELLING YOURSELF – APPLICATION FORMS

When you apply for a job you may be asked to fill in an application form. This can be a bit of a headache, but it's not always as bad as it looks.

APPLICATION FORMS

WHAT DO THEY WANT?

The employer wants to know a bit about you. First he wants to know obvious things like your name, age and address. But he also wants to know what kind of things you have done and what you've got to offer. Sometimes the form will help the employer to handle the interview.

THE QUESTIONS

Some of the questions may seem pointless, like your hobbies, or whether you're married or not.

It's important to answer them. They're trying to get an idea of what you're like to help them decide whether to interview you. If you want the job, you've got to play the game.

TIPS FOR FORMS

1. Make a list of personal details, like address, what school you went to and when.
2. Read the form carefully before you start.
3. Make sure your writing is neat.
4. Write in pen.

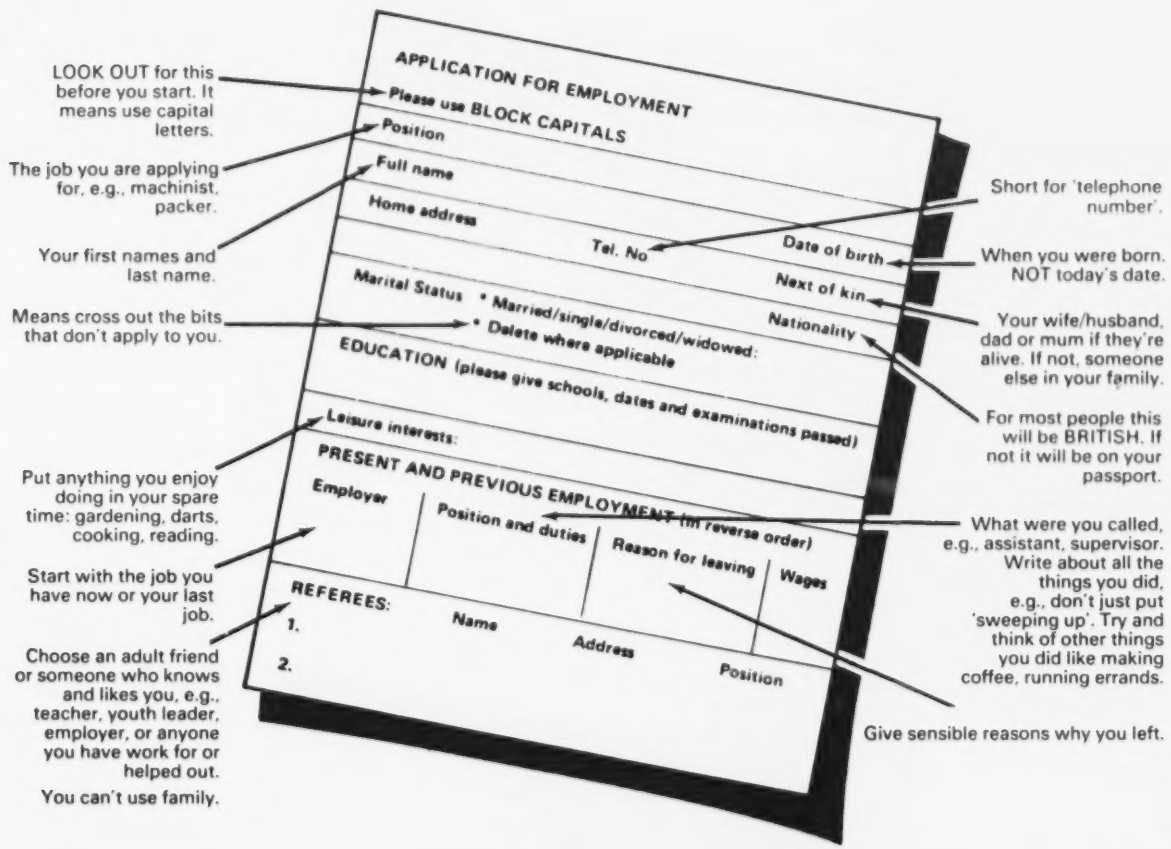
SENDING IT IN?

1. Write your answers out in rough first, or use a pencil and then go over it in ink.
2. Get someone to help you fill it in, if you're not sure.
3. Get someone to check it before you send it off.
4. Keep a copy if you can.

DOING IT THERE?

1. Take your list of personal details with you.
2. Check carefully for any mistakes you may have made and correct them neatly.

An application form explained


APPLICATION FOR EMPLOYMENT
Please use BLOCK CAPITALS
Position
Full name
Home address
Tel. No
Date of birth
Next of kin
Nationality
Marital Status * Married/single/divorced/widowed:
* Delete where applicable
EDUCATION (please give schools, dates and examinations passed)
Leisure interests:
PRESENT AND PREVIOUS EMPLOYMENT (in reverse order)
Employer
Position and duties
Reason for leaving
Wages
REFEREES:
1.
2.
Name
Address
Position
LOOK OUT for this before you start. It means use capital letters.
The job you are applying for, e.g., machinist, packer.
Your first names and last name.
Means cross out the bits that don't apply to you.
Put anything you enjoy doing in your spare time: gardening, darts, cooking, reading.
Start with the job you have now or your last job.
Choose an adult friend or someone who knows and likes you, e.g., teacher, youth leader, employer, or anyone you have work for or helped out.
You can't use family.
Short for 'telephone number'.
When you were born. NOT today's date.
Your wife/husband, dad or mum if they're alive. If not, someone else in your family.
For most people this will be BRITISH. If not it will be on your passport.
What were you called, e.g., assistant, supervisor. Write about all the things you did, e.g., don't just put 'sweeping up'. Try and think of other things you did like making coffee, running errands.
Give sensible reasons why you left.

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SELLING YOURSELF – INTERVIEWS

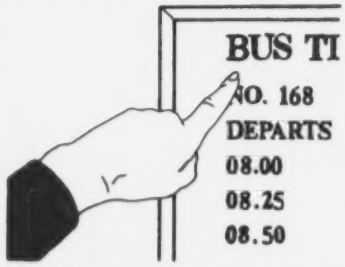
If they want to see you, you've got a good chance. Make the most of it.

INTERVIEWS

GETTING READY

'I've got to be there by 10 o'clock'.

How far away is it? Do you need to catch a bus?



If so allow for the extra time.

MAKING A GOOD IMPRESSION

Be neat and tidy. Be on time or a bit early.

THE INTERVIEW

★ Be prepared to shake hands.
★ Don't sit down until you're asked to.
★ Don't smoke unless you are offered one.

QUESTIONS YOU MIGHT GET ASKED

What have you done in the past?

What do you know about this firm?

Why have you applied for this job?

★ Have some good answers ready.
★ Be prepared to fill in an application form – (see page 51).
★ Try not to answer with just YES or NO. Think out the answers before you go.

ASKING QUESTIONS

They sometimes ask if you have any questions. You could ask things like this:

Is there any training?
What is the pay?
What are the hours?
Is there a canteen?
Is there a union?
Do I have to work Saturdays?

IF you don't get this job don't worry –

★ Someone may have been better than you.
★ You may not have shown your best side.
★ The job may not have been right for you.

HOW DID IT GO?

Try and think about how it went. Did you sell yourself? Could you have done it better?

THINGS TO READ

Getting the Right Job by Chris Parson and Angela Neustatter – Pan.

Getting the Job You Want by Howard Dowding and Sheila Boyce – Ward Lock.

The Job Finders Book by Ruth Sandys and Alexa Stace – Kogan Page Ltd.

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